Social Sciences and Space Exploration

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Social Sciences and Space Exploration

New Directions for
University Instruction

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National Aeronautics and
Space Administration

November 1984

This book is dedicated to the late Dr. Frederick B. Tuttle, the prime mover and inspiration behind this volume, which links the social sciences and the space program.

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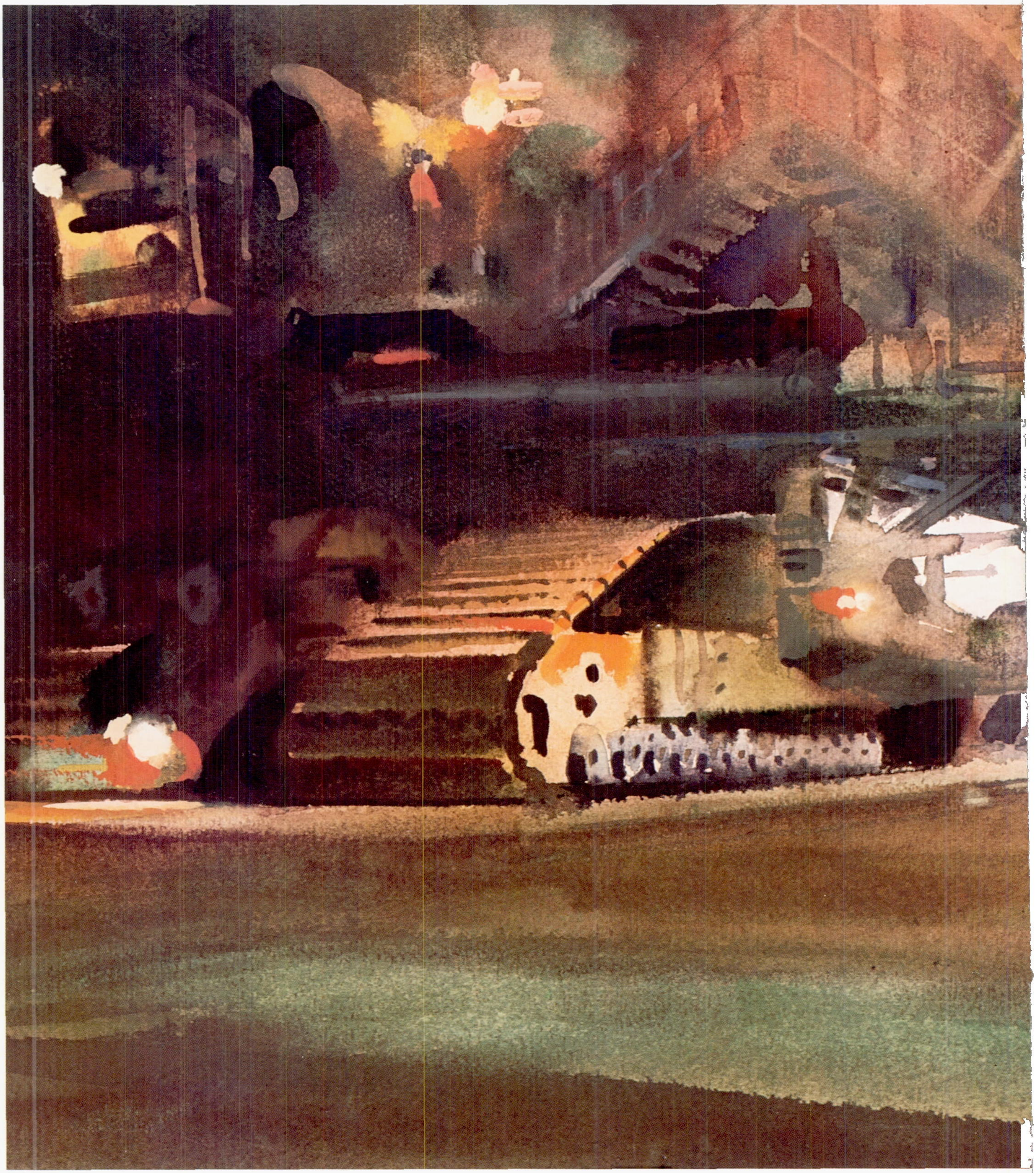
The Day Before the Launch by Frank Wright, oil, 28″ by 60″.



The Crawler—Rollout of the Enterprise by Arthur Shilstone, watercolor, 22½" by 29½".

ORIGINAL PAGE
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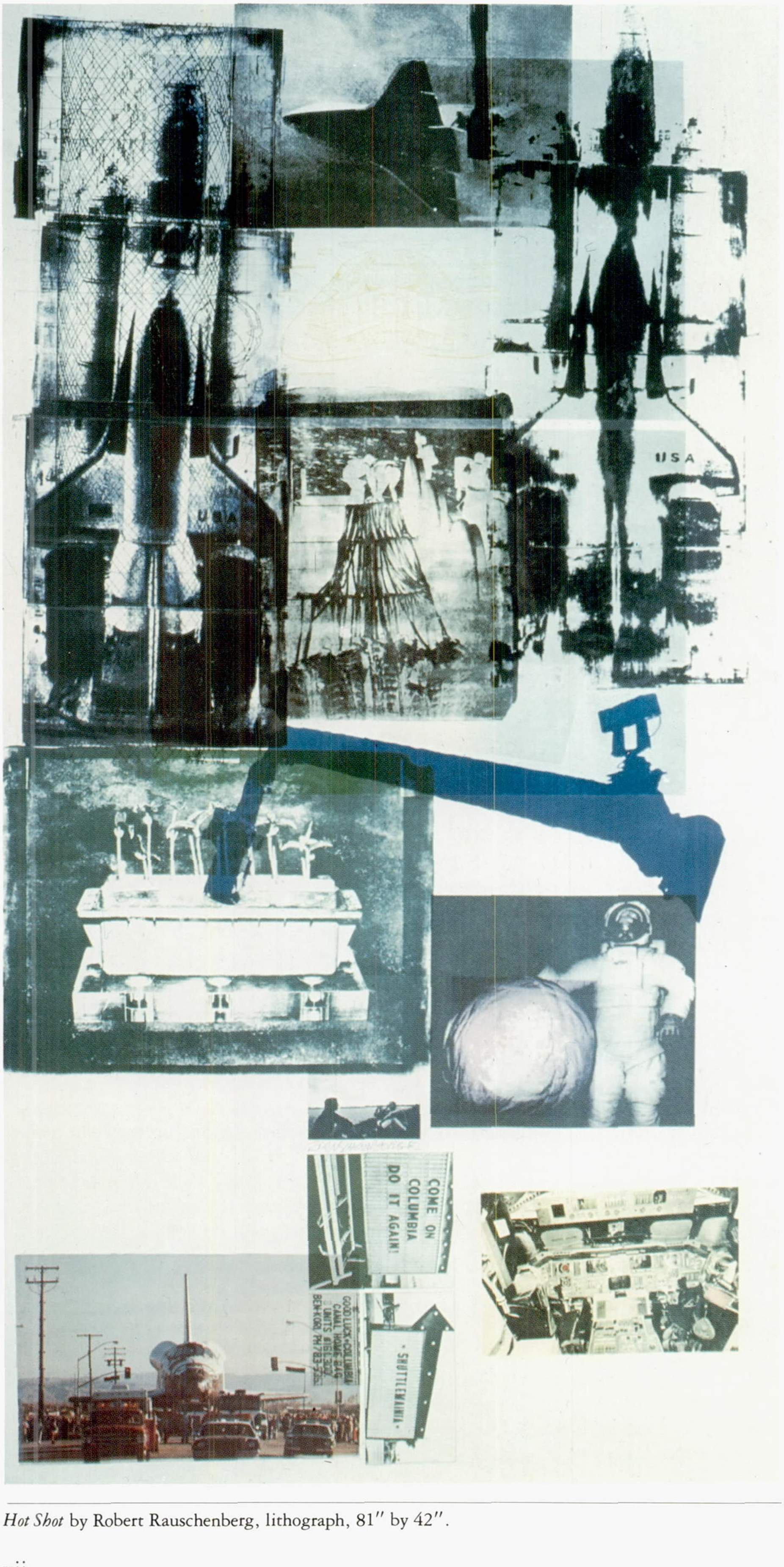
Preface

During the 1970s, college and university faculty reintensified efforts to teach and research the social science and humanities aspects of the space program, a development attributable in large part to the Space Shuttle. A 1978 survey of faculty suggested the need for a single volume that united introductory material on the various social science disciplines and the classroom experience of faculty already teaching in the field. In the absence of such a resource, individual instructors had to start from scratch—organizing lecture notes, bibliographies, and research topics for their students, only to discover later that such tasks already had been undertaken by one or more professionals at other institution(s).

In response to this need, NASA issued a contract to Georgetown University to produce such a book, focusing primarily on the Space Shuttle era (1980s and 1990s). From the outset, NASA and the authors understood that not all social science and humanities disciplines could be represented in the volume, because of both the lack of sufficient materials in some fields and the strict page limitation on the book itself.

This project relied heavily on the efforts of a large number of people beyond the editors and contributors. We want to make special note of support and direction from the late Dr. Frederick B. Tuttle, a leading NASA authority on aerospace education, who enthusiastically promoted the project and supplied insights crucial to the volume's development. The editors are especially indebted to the NASA program officers monitoring the project—William Nixon, Jesco von Puttkamer, and Gregory Vogt—for their constructive criticisms and continued support. We also would like to gratefully acknowledge the administrative and production assistance provided by: David Hannah, Jr.; the department of biology at Georgetown University; Nancy Walsh; and Karen Dewey, Cheryl Newson, and Nancy Switkes.

T. Stephen Cheston
Principal Investigator
January 1983



Hot Shot by Robert Rauschenberg, lithograph, 81″ by 42″.

Introduction

The relationship between technology and society is a subject of continuing public interest, in large part because technological change and its effects constantly confront and challenge the various sectors and members of society. For example, progress in automation and robotics can render whole categories of employment obsolete in sectors such as the automotive industry; increases in air travel speeds can stimulate the formation of new service industries; advances in computer capabilities can revolutionize education, many professions, and personal tasks; continuing developments in electronic communication can restructure national and international business management and meeting practices and undercut U.S. Postal Service operations—examples of technological change abound throughout society and the economy. Public interest in technological change is further documented by the strong popular response to books by authors such as Marshall McLuhan, Alvin Toffler, and Herman Kahn, who interpret the impact of technological change on society.

College students are especially concerned about technological change, knowing that they must cope with the pervasive and escalating effects of wide-ranging technological change. An individual's professional life spans approximately forty-four years, so a student graduating in the early 1980s will not retire until the late 2020s. Illustratively, in the forty-four years from 1938 to 1982, technological developments included the advent of jet air transportation, television, atomic weapons, and computers—profound changes that affect everyone. Students interested in technological change over the next half century thus do not reflect simply youthful fascination with novelty, but also genuine pragmatic concern about personal and societal survival and advancement.

Concomitantly, social scientists have been intensifying their efforts to understand the relationship between technology and society. This complex and intriguing subject is replete with questions of value and points of controversy, such as: What is the precise definition of technology? To what extent does technology mold the fabric of society and vice versa? Is individual freedom enhanced or circumscribed by technological change? Does technological change promote or hinder the refinement and application of ethical values?

The Space Shuttle represents a particular type of technological change and is described in detail in Chapter One; at this point a thumbnail sketch is useful. As a technological artifact, the Shuttle is a recently-developed general purpose machine that constitutes the centerpiece of a system designed to provide bulk transportation services

to low Earth orbit (roughly altitudes from 161 to 965 kilometers, or 100 to 600 miles). The Shuttle cannot fly to the Moon or the planets or even geosynchronous Earth orbit (an altitude of 35,881 kilometers, or 22,300 miles), but smaller machines that can be boosted to higher orbits or lunar or planetary missions can be transported to low Earth orbit by the Shuttle. Naturally, the Shuttle design accommodates the special environmental characteristics of space (hard vacuum, microgravity) and the Earth's atmosphere. The U.S. government conceived and financed the Shuttle, although the European Space Agency and Canada provided some of the developmental funds. The U.S. Congress continually subjected the Shuttle development project to intense scrutiny, as the social and political climate of the 1970s proved generally inauspicious for large-scale high-technology projects. The market for Shuttle services is a mix of private and government users in both the U.S. and foreign countries. For the most part, users will be institutions rather than individuals.

The social science study of space technology in general provides a perspective useful to a study of the Shuttle system. During the 1960s and 1970s a variety of books, articles, studies, and research projects addressed the relation of space technology to one or several aspects of society. By 1978 the volume of activity was sufficient to prompt NASA to commission an inventory and analysis of research on space technology produced by the social science and humanities disciplines.[1]

A review of the historical development of this research demonstrated that the number of social science studies generally fluctuated with the volume of space activity and the level of public interest. During the 1960s social science research was stimulated by NASA, which responded both to the dictates of the 1958 Space Act that created the agency and to the concerns of officials who realized that the effects of space technology were rippling unevenly through society. A survey of NASA-sponsored social science grants and contracts from 1958 to 1968 found that NASA had spent about $35 million to "attempt to understand the socio-economic effects of its actions and programs."[2] NASA-sponsored research tended to concentrate on the effect of NASA activities on local economies: for example, the study of the Marshall Space Flight Center in Huntsville, Alabama and analyses of human factors related to manned missions (astronaut behavior, among other topics). NASA also encouraged more general research projects, such as those that resulted in the publication of *The Railroad and the Space Program: An Exploration in Historical Analogy* and *Social Indicators.*[3] (The latter work is discussed below under Impact Analysis.)

Independent of NASA sponsorship, academic researchers investigated a variety of space policy topics, including public policy formulation processes, international political issues, and general historical studies.[4] However, the dispersed nature of the works and their general submersion in established disciplines (e.g., political science and history) made it difficult to identify anything approaching a "space social science" discipline. Moreover, the overwhelming majority of professionals in the social sciences did not take space technology seriously, regarding it as a field apart and unrelated to the regular commerce of the disciplines.

This neglect by the social science and humanities academic communities widened with the radical decline of public support for space activities that occurred in late 1969 and 1970. The minimal academic attention to space studies that characterized this period was often more hostile and political than scholarly; for example, in 1969 the Association of American Geographers passed a resolution questioning the role of space in our national priorities.[5] This period of academic quiescence lasted for the first half of the 1970s.

A modest upsurge in social science interest in space occurred around the middle of the decade. A precise reason for such interest is difficult to pinpoint but may have been attributable in part to increased public discussion on means of utilizing space to encourage economic and social growth. As the Space Shuttle development process matured, the system's capabilities became more familiar and real to the public. In addition, the public manifested considerable frustration over the potential and actual societal constraints imposed by so-called limits to growth. Although the theory and reality of limits to growth were hotly debated, many scholars acknowledged the serious risks inherent in economic and social systems that rely on the ultimately finite resources of one planet. This realization stimulated some scholars to think more audaciously, considering a wide range of solutions, including the exploration and use of space as a possible means of circumventing raw material, energy, agricultural, and pollution constraints.

Complementary to this rethinking, the scientific and engineering communities began to develop and evaluate concepts that called for the macro-utilization of space. Such concepts included a variety of plans for space industrialization and manufacturing, satellite solar power generation, and even space habitation. Of course, social scientists were not able to assess the technical feasibility of these plans—for purposes of discussion, social scientists often assumed the fundamental credibility of the plans (in the long term if not the short term) as long as the professional technical community devoted serious and detailed discussion to them. Importantly, during this period the idea of permanent living facilities in space assumed a reality, in contrast to the previous relegation of the topic largely to the realm of science fiction. Technical and popular discussions about the long-term potential for space colonies and space settlements enthused many people, who frequently overestimated the technical feasibility and near-future possibilities of space habitats, despite constant admonitions from NASA and other members of the space technology community. Furthermore, the imagery of living permanently in space prompted many to relate space technology to the social sciences for the first time. This new relationship triggered the establishment of college courses, study programs, and even research centers specifically devoted to analyzing issues pertinent to living in space.[6]

The spontaneous academic interest in space that emerged in the mid-1970s tended to focus on long-term issues, overlooking the impact of space technology on contemporary society and concentrating more on long-term possibilities and effects. Consequently, scholarship was often speculative and became closely interwoven with futurism. However, some researchers who initially approached the subject of space by analyzing its futuristic aspects subsequently began to address near-term questions.

The Space Shuttle era effectively began in 1982 with the Shuttle's first operational flight. The Shuttle flights and missions will provide increasing amounts of material and data for social science study. The hallmark of this stage of the U.S. space program is the rapid expansion of projects central to the economic utilization of space. This Shuttle era contrasts substantially with the Apollo era, which was almost totally exploratory (with the primary exception of communication satellites). As an activity, economic utilization links space to the more intrinsic interests of the social sciences and reduces the sense of separation between space and the social sciences that has isolated many professionals from space studies. Of course, this is not to say that there will be an avalanche of academic interest in near-term space issues, but rather that the groundwork is being laid to bring space studies more into the mainstream of the social science disciplines.

I. Organization of the Social Science Study of the Shuttle

A framework that can be applied to the general study of the Shuttle was identified by an intensive review of space-related social science literature conducted during the 1978 NASA study of the social sciences.[7] The study clustered social science research related to space into three main categories: Impact Analysis, Orbital Human Factors, and Development Factors.[8] Each is discussed briefly below.

A. Impact Analysis

Impact Analysis includes the range of comprehensive multidisciplinary studies that evaluate the effects of major space and technological projects on national and international societies (and on subsections of those societies). Impact Analysis takes a variety of forms and employs a number of different methodologies that all apply a breadth of social science knowledge to assess the full consequences of a particular technological change. More often than not, the aim of Impact Analysis is to assist policymakers who must decide whether or not to initiate or approve a technological change (and if so, in what form). Much of such analysis focuses on a comparison of technological options that address particular economic or social needs. Advanced forms of Impact Analysis examine the multifold reciprocal feedback relationships that even a modest technological change can generate.

Impact Analysis represented an intellectual invention of the late 1960s and early 1970s and evolved as part of the burgeoning academic study of technology in its social context.[9] Coincidentally, MIT professor Raymond Bauer produced one of the first works to develop an Impact Analysis methodology, working under contract to NASA to examine the effects of space exploration on society. Discovering that existing methodologies could not adequately measure these effects, Bauer developed his own system of indices that became a principal methodology and teaching guide, published under the title *Social Indicators.*[10]

Following Bauer's pioneering work, researchers refined two other approaches to Impact Analysis that deserve note. The first, Technology Assessment, is designed specifically for the public policy process and considers not only the cost and engineering feasibility of a new technology, but also the impact of the technology on: legal, political, and social institutions; the family; the environment; international relations; land use planning; and demographic patterns.[11] The second Impact Analysis methodology, Social Impact Assessment, is designed as a flexible and adaptable tool for analyzing the direct and indirect effects of technological changes.[12]

Some Impact Analysis studies focus on space-related technologies; such studies include Vary T. Coates' *Technological Assessment of a Space Station* and a nearly $20-million multivolume study conducted for the Department of Energy on satellite solar power system concepts.[13] Periodically, studies have concentrated on the space program's economic impact; examples include Mary A. Holman's "Economic Impact of the Manned Space Program in the South" and Michael K. Evans' *The Economic Impact of NASA R&D Spending.*[14]

B. Orbital Human Factors

Orbital Human Factors includes studies of human needs and behaviors during and after operations outside the Earth's biosphere. Such study is unique to space technologies, which expose humans to the special physical characteristics of space. For example, a key feature of space is the continuous risk of direct and lethal exposure to the vacuum of space; this characteristic requires that humans always operate within protective encapsulation, be it a tiny Mercury capsule, a space station, or a relatively large Moon base. To date, physical movement in space always has been limited, and group living conditions have been marked by both practical constraints and high population density relative to the available living space. Moreover, the omnipresent fear of potential physical danger resulting from a damaged space facility constitutes another feature intrinsic to the space environment.

Orbital Human Factors is discussed in the Psychology and Sociology segments of Chapter Two. Orbital Human Factors problems pose a particular challenge to these disciplines by requiring further advances in their powers to predict human behavior.

C. Development Factors

Development Factors includes studies of societal characteristics that stimulate and guide the creation of space technology. Development Factors is a two-tier category. The first tier addresses the cultural images, values, and interactions that affect attitudes toward space and

space ventures. For example, such factors include science and exploration as a Western value and the relationship of space technology to images of power, economic achievement, and social growth. These factors are essentially inner impulses that prompt or facilitate decisions to devote resources to space technology. The second tier analyzes the particular mechanisms used to operationalize these impulses. Such mechanisms encompass the issues, processes, institutions, and their interactions that affect the direction of space activity. For instance, why does one nation concentrate at a particular time on unmanned planetary exploration and another on near-Earth manned space activity? Factors relevant to this question include public opinions, systems of public policy formulation, national defense implications of space projects, and methods for the economic institutionalization of space activity.

Studies of Development Factors almost always emerge without the stimulation of government financial support. They arise mainly from the academic community but also appear in other sectors. Examples of first-tier Development Factors studies include William Sims Bainbridge's *The Space Flight Revolution—A Sociological Study* and George S. Robinson's *Living in Outer Space.*[15] Examples of second-tier studies include John M. Logsdon's "The Space Shuttle Decision: Technology and Political Choice" and Michael Kinsley's *Outer Space and Inner Sanctums.*[16]

II. Role, Structure, and Use of the Book

The book's role is to serve as a resource for the increasing number of college faculty and students who are or soon will be interested in the social science implications of space technology. The focus is on the Space Shuttle, because the vehicle will function as the principal tool for U.S. space activities during the 1980s and 1990s. The book is designed to provide introductory material on a variety of space social science topics to help faculty and students pursue teaching, learning, and research. The materials were gathered largely from college faculty members who have taught and/or researched the requirements and impacts of space technologies within a social science or humanities context. The intent here is to share the all-too-often narrowly accessible experience of social science professionals on issues such as: how instructors relate space technology to their respective disciplines; effective curriculum formats; and research topics of particular interest to students. The book is not comprehensive but rather addresses select aspects of relationships between the Space Shuttle and society. A comprehensive guide is currently infeasible because of two factors: many of the Shuttle's social effects will not manifest themselves for several years; and social science and humanities studies of space technology are still at a relatively rudimentary stage, and some disciplines are not yet adequately represented.

The book is divided into four sections. Chapter One outlines the characteristics and attributes of the Shuttle and the technologies scheduled for transport to orbit. This brief review offers as clear a view as possible of the precise nature of the seminal technologies, seeking to provide a kind of "technological stem" as a base of reference for social scientists and humanities faculty members and researchers. Chapter Two is divided into segments according to discipline, allowing faculty members to relate a specific discipline to space technology and to adapt space-related issues to the classroom teaching of a specific discipline. Chapter Three presents materials useful for teaching interdisciplinary courses and topics, including observations from college instructors who have offered interdisciplinary space-related courses and insights from faculty members who have analyzed space technologies in a debate format. The appendices include curricula materials and bibliographies that are perhaps most useful in actual curriculum development rather than the identification of teaching objective(s).

Footnotes

1. U.S. National Aeronautics and Space Administration. *A Study of the Potential Impacts of Space Utilization.* Final Report NASW 3152, by the Space Utilization Team, Graduate School, Georgetown University, 1978.

2. Mary A. Holman. *The Political Economy of the Space Program.* Palo Alto, CA: Pacific Books, 1974.

3. Bruce Mazlish (ed). *The Railroad and the Space Program: An Exploration in Historical Analogy.* Cambridge, MA: MIT Press, 1965. Also: Raymond A. Bauer. *Social Indicators.* Cambridge, MA: MIT Press, 1966.

4. John M. Logsdon. *The Decision to Go to the Moon—Project Apollo and the National Interest.* Chicago: University of Chicago Press, 1970; Don E. Kash. *The Politics of Space Cooperation.* Lafayette, IN: Purdue University Press, 1967; Patrick Moore. *Space: The Story of Man's Greatest Feat of Exploration.* New York: Natural History Press, 1969.

5. *Association of American Geographers Newsletter.* Vol. 3, No. 8, October 1969 and Vol. 3, No. 10, December 1969.

6. For example, a course on "Space Colonization" at Stanford University (1978 and 1979) and one on "The Colonization of Space" at the University of North Florida (1976-78). At Niagara University, the Center for the Study of Human Communities in Space was established (and has since been renamed the Space Settlements Studies Project).

7. See footnote 1.

8. In the original study, this third category was referred to as "General Space Social Science."

9. Information on Impact Assessment here is largely drawn from: T. Stephen Cheston. "Space Social Science: Suggested Paths to an Emerging Discipline." *The Space Humanization Series.* Vol. 1, 1979.

10. See footnote 3.

11. Joseph F. Coates. "Technological Assessment." *Chemtech.* June 1976.

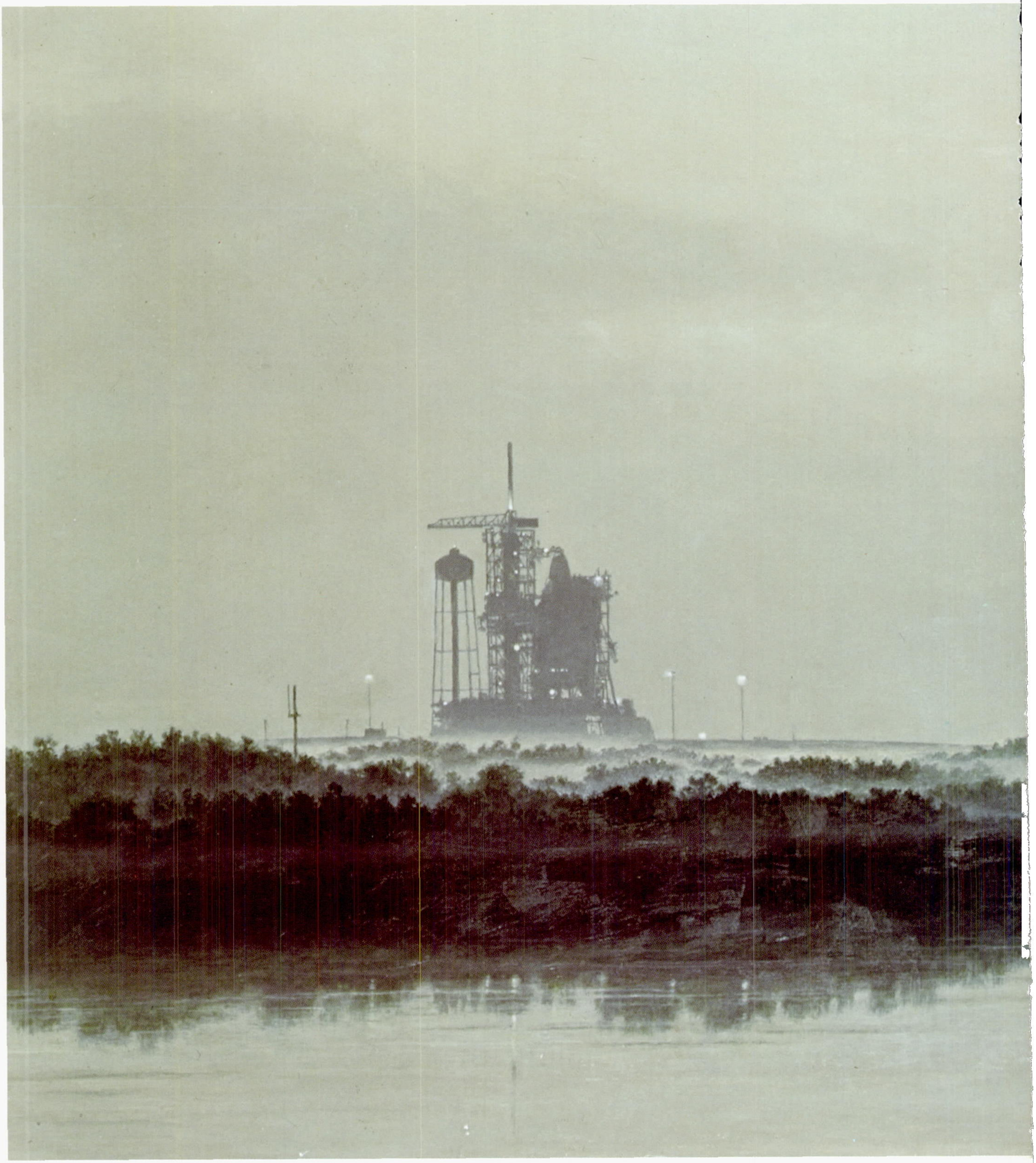
12. Magoroh Maruyama, et. al. *Social Impact Assessment: An Overview.* Corps of Engineers IWR paper 75, 1975, p. 7.

13. Vary T. Coates. *Technological Assessment of a Space Station.* George Washington University Program in Science, Technology, and Public Policy, 1971. An overview of the results of the satellite solar power study is found in: U.S. Department of Energy. *Satellite Power Systems (SPS) Societal Assessment.* DOE/ER 10041-T12, by PRC Energy Analysis Company.

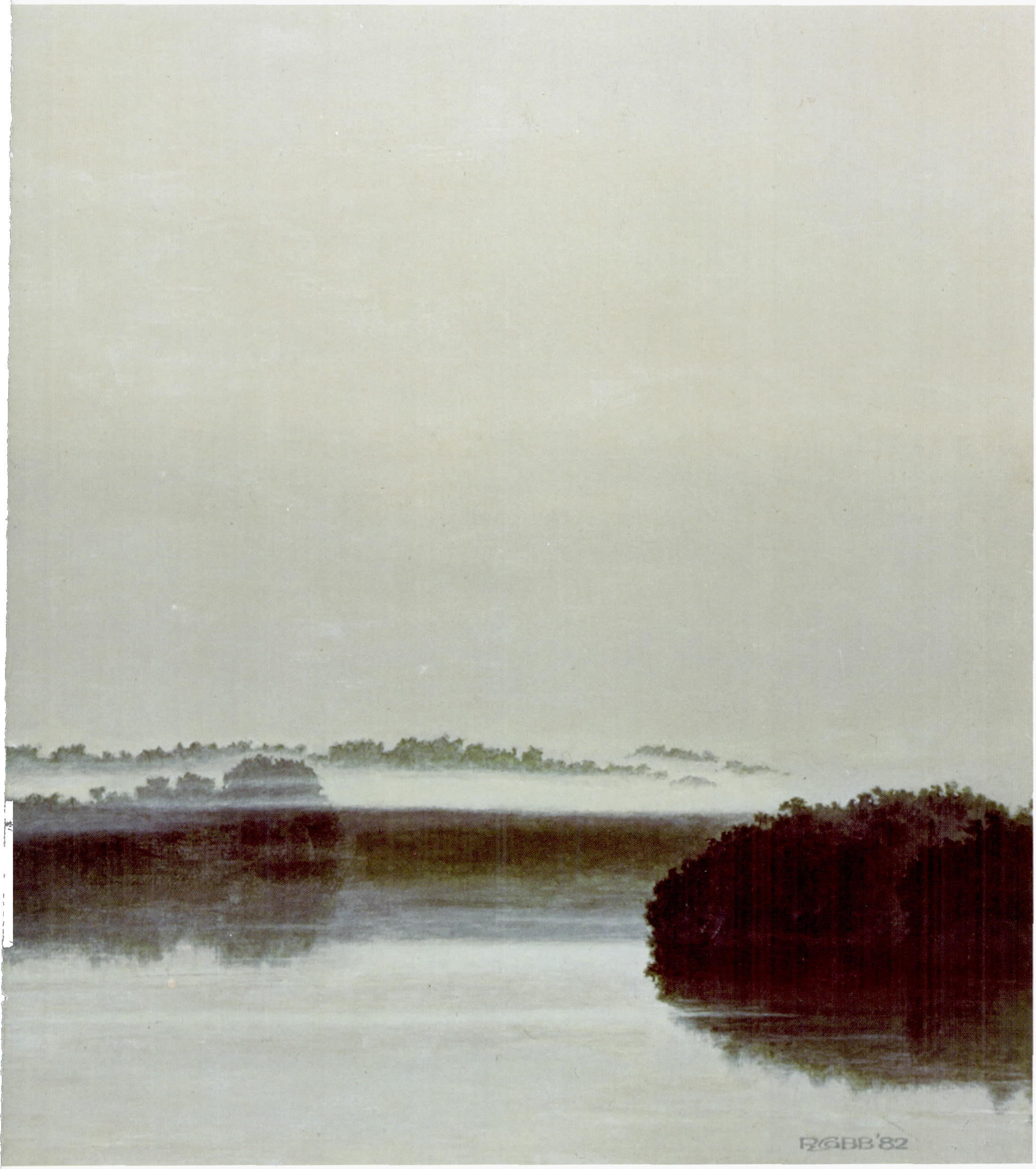
14. Mary A. Holman. "Economic Impact of the Manned Space Programs in the South." *Monthly Labor Review.* 1968; Michael K. Evans. *The Economic Impact of NASA R&D Spending.* NASW 2741, by Chase Econometric Associates, 1976.

15. William Sims Bainbridge. *The Space Flight Revolution—A Sociological Study.* New York: John Wiley and Sons, 1976; George S. Robinson. *Living in Outer Space.* Washington, D.C.: Public Affairs Press, 1975.

16. John M. Logsdon. "The Space Shuttle Decision: Technology and Political Choice." *Journal of Contemporary Business.* August 1978; Michael Kinsley. *Outer Space and Inner Sanctums.* New York: John Wiley and Sons, 1976.



T-Minus Three Hours and Holding by Ron Cobb, acrylic, 25″ by 45″.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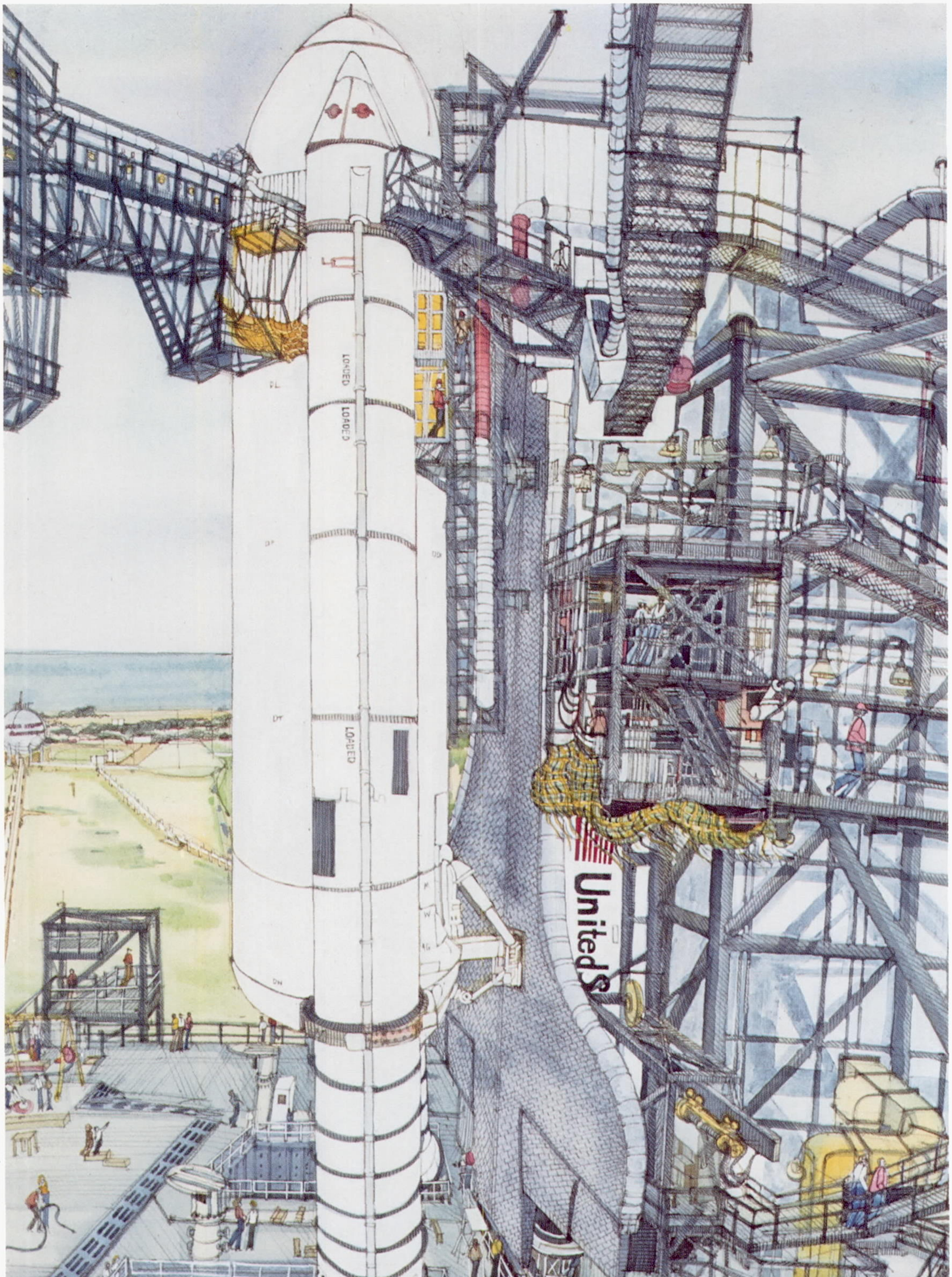


Preparations of the Space Shuttle Columbia by Mark McMahon, watercolor, 39½″ by 25½″.

Chapter One

Space Technologies

More than twenty-five years ago, the first primitive spacecraft tentatively probed the outer space environment surrounding Earth. Above the filtering shroud of the atmosphere, the universe and the Earth itself assumed new clarity. The Earth functions not merely as a planet circling an average star, but also as a dynamic life support system traveling through and interacting with the universe. The Earth represents a spaceship with billions of astronauts on board—a system unique to the solar system and perhaps to the universe as well.

Each new spacecraft launch produced both new discoveries and subtle (then major) changes in the day-to-day lives of people. Spaceflights generated better communications, improved weather monitoring, innovative products, and new jobs.

As each new space mission posited more questions than answers, increased launch capabilities were required. The first rockets were essentially modified missile systems with restricted payload capacities and limited orbital elevations. For a time, new microelectronics industries helped pack more instruments into smaller spaces, but the space program required still larger payload capacities and more powerful boosts to interplanetary space. NASA built and flew larger rockets, each more complicated and expensive than the last.

By the early 1970s, budgetary pressures forced an evaluation of launch vehicle design. Although the existing family of launch vehicles had grown and diversified to meet a variety of challenges, each vehicle still was expendable. The need for greatly increased launch services, combined with budgetary constraints, seemed to mandate a reusable vehicle capable of repeated trips to orbit. In 1972, the National Aeronautics and Space Administration began a program to develop the world's first spaceship, a reusable vehicle—the Space Shuttle.

I. The Space Shuttle

The launch of the first Space Shuttle on April 12, 1981 initiated a new era in space travel. Fifty-four and one-half hours later, the Columbia and its crew, John Young and Robert Crippen, glided to a safe landing on the high desert at Edwards Air Force Base, California.

The Space Shuttle represents a new breed of launch vehicles. The Shuttle takes off as a rocket, operates in orbit as a spacecraft, and returns to Earth as a glider. Following refurbishment and attachment of a new propellant tank and solid rocket boosters, the Space Shuttle is ready for a new space mission.

The orbiter constitutes the central feature of the Space Shuttle; Columbia is the first of four orbiters currently scheduled for manufacture. Together the orbiters will form a fleet of reusable spaceships that will carry payloads into orbit for many years. A delta-winged aerospace vehicle comparable in size to a DC-9 jet, the Shuttle orbiter houses a flight deck and crew quarters in the nose. The flight deck incorporates all control functions, and a lower deck provides living accommodations. As many as seven astronauts (three flight crew members and four specialists) can fly into space on board the orbiter, although the normal crew ranges from two to four astronauts. The midsection of the orbiter is a cargo bay large enough to transport one and one-half buses. The cargo bay accommodates a total of 29,500 kilograms (65,000 pounds) of satellites and other payloads, and 14,500 kilograms (32,000 pounds) can be returned to Earth if necessary.

At liftoff, the three main engines in the orbiter's tail and the two solid rocket boosters produce nearly 30 million newtons (6 and ½ million pounds) of thrust. Approximately two minutes into flight, the boosters separate and parachute into the ocean for recovery and reuse. Over the next six and one-half minutes, the giant external tank mounted on the orbiter's underside is emptied of liquid hydrogen and oxygen used by the orbiter's three main engines. The external tank is jettisoned and destroyed by atmospheric friction on reentry. Any surviving pieces fall into preplanned remote ocean areas.

Two small orbital maneuvering system engines accomplish the final thrust into orbit. Pods on either side of the orbiter's vertical tail store the propellants for these engines. While in space, all maneuvering depends on these two engines, and forty-four thrusters mounted in the nose and tail provide attitude control.

In orbit, large clam-shell doors in the mid-section of the orbiter open to uncover a cargo bay 18.3 meters in length by 4.6 meters in diameter (60 by 15 feet). As many as four satellites can be carried to orbit in the bay at one time. Satellites requiring repair or maintenance can be maneuvered into the cargo bay by a 15-meter-long mechanical arm, the Remote Manipulator System (financed and developed by the National Research Council of Canada). The arm also deploys satellites and other spacecraft in orbit. Additionally, the cargo bay serves as a platform for scientific research: staffed laboratories can be housed in the bay, and automatic experiments can be exposed directly to the outer space environment. Furthermore, the orbiter cargo bay functions as a staging point for spacecraft destined for higher orbits than the nominal 160- to 970-kilometer (100- to 600-mile) range of the Shuttle. Small upper stage rockets will accelerate payloads to geosynchronous orbits and interplanetary courses.

To return to Earth, the orbiter rotates in a tail-first direction. A two and one-half minute burn of the orbital maneuvering system engines slows the vehicle as it swings around nose first and begins the reentry process. Thirty minutes prior to landing, the orbiter encounters the upper atmosphere at an altitude of approximately 122,000 meters (400,000 feet). Using combinations of thrusts produced by the small reaction control rockets, the orbiter realigns into a nose-high attitude.

Intense friction between the orbiter and the thin atmosphere heats portions of the exterior to temperatures exceeding 1,260°C (2,300°F). A dense surface insulation called reinforced carbon/carbon is attached to the nose and leading edges of the wings. This substance is a carbon cloth impregnated with additional carbon, treated with heat, and then coated with silicon carbide. A silica fiber tile covers most other areas of the orbiter skin. The tile receives a glassy ceramic black coating for the underside of the orbiter and a white coating for the top. Still other areas of the orbiter skin are covered with a silicon-coated Nomex felt blanket material.

As air density increases, vehicle speed converts the orbiter from a spacecraft to an aircraft. Attitude control shifts from the reaction control rockets to the aerodynamic surfaces on the wings and tail. By the time the rear landing gear touches down, the orbiter velocity has slowed from an orbital speed of 28,160 kilometers per hour (approximately 4.9 miles per second) to 350 kilometers (220 miles) per hour.

Back on the ground, the Shuttle orbiter undergoes a refurbishment and repair process: expendable supplies are replaced; returned payloads are removed and new ones inserted; a new external tank is mated to two refueled, reusable solid rocket boosters; and the orbiter is joined to the tank and boosters in a vertical position. Within several weeks, the Space Shuttle can return to space for another mission. The orbiter is designed for one hundred missions and the solid rocket boosters for ten to twenty missions.

II. Space Transportation Prospects and Limitations

The Space Shuttle constitutes the main component of NASA's Space Transportation System (STS). Along with some existing low-cost expendable launch vehicles, the Shuttle offers users an unprecedented degree of reliability and versatility at a considerably lower price than previously available. Because the orbiter includes a cavernous cargo bay, spacecraft and satellite designers have more freedom in choosing components; former constraints required custom-built components to fit into comparatively tight payload compartments. This Shuttle advantage alone promises to produce major savings for payload developers.

To reduce design complexity, oversized payloads can be launched in a disassembled form for assembly in space by the Remote Manipulator System (RMS) or by spacesuited astronauts. The RMS represents an analog to the human arm and can be operated automatically or by astronauts working on the orbiter flight deck. For more intricate assembly tasks, astronauts will don space suits and clamber over spacecraft, possibly attaching solar cell panels and experiment booms. For additional mobility, a compressed-gas manned maneuvering unit (MMU) can be worn to propel astronauts to desired locations. Human support for satellites, spacecraft, and on-board experiments constitutes one of the more valuable features of STS.

Small booster rockets that can be carried in the orbiter cargo bay will raise satellites to higher orbits than those of the Shuttle. Boosters such as the Spinning Solid Upper Stage (SSUS) and the Inertial Upper Stage (IUS) will lift satellites to geosynchronous orbit. Spacecraft targeted for interplanetary travel may be boosted by a modified version of the Centaur upper stage presently used by Atlas and Titan launch vehicles.

The utility and versatility of the STS is perhaps best demonstrated by user demand—the Shuttle has booked over seventy operational flights (as of June 1981). Additional requests for flight accommodations are in negotiation. Moreover, potential STS users have substantially increased the number and scope of studies analyzing potential Shuttle-based space operations. As the system matures, the demand for STS flights and services will likely expand significantly.

Indeed, NASA studies of STS utilization indicate that near-term user needs call for longer missions and greater on-board electrical power than the baseline Shuttle can provide, particularly for missions in fields such as life sciences, materials processing, new science and applications payloads, and high-capability communications systems. To satisfy these needs, NASA plans to develop a deployable solar cell array, the power extension package (PEP). PEP would be mounted on the Shuttle RMS, which will position and hold PEP outside the orbiter cargo bay. Increased power would allow the vehicle to extend orbital stay time from seven to thirty days.

Long-term studies of the potential for Shuttle-derived technologies demonstrates that continued enhancement of the basic STS may generate increasingly large payoffs for individual users (governmental, commercial, and scientific), as well as for the nation and its international partners.

To achieve these payoffs, at least two conditions must be satisfied. First, STS enhancement must follow a clearly defined evolutionary path, designed to: expand and maintain space policy options; respond to changing national goals; and accommodate varying economic, social, security, and political environments. Second, proposals for new Shuttle-derived space technologies should be accompanied by ongoing, objective assessments of the socioeconomic implications of these technologies.

III. Three Stages of Shuttle-Based Space Technology Development

Projections of future space development can be too conservative, too optimistic, or simply incorrect. A NASA-sponsored seminar of long-range space planners informed NASA in 1980 that:

> When the committee began its discussion of these arcane conjectures it was aware of an earlier failure. We recall that in 1937 when Franklin Delano Roosevelt convened a group of our most distinguished scientists to advise him on impending technological advances which might influence American policy, these outstanding minds did not anticipate nuclear power, rocketry, antibiotics, radar or the electric computer, all of which were about to surface.

Clearly, the pace, direction, and scope of Shuttle-based space activities depend on several factors, including, for example: technological feasibility; the level of demand for space services, determined by a variety of user communities (civil and military government groups, commercial enterprises, and other nations); the economics of space-based versus terrestrial goods and services; competing national scientific, security, political, and economic priorities; and the national and international legal and regulatory structures governing space activities.

In contrast to the preceding discussion of the basic Space Transportation System, this section focuses on future Shuttle-derived space technologies and activities. Of necessity, such a review must be speculative. Much of the value of social analyses of space technologies lies in anticipating the societal implications of the widespread adoption of new space systems. Using such analyses, space technologies most likely to benefit society may be isolated early in the research, design, and development stage; concomitantly, some space systems resulting in little or no benefits or producing counterproductive impacts may be discerned before large-scale commitment and implementation.

To achieve this goal, social studies must examine proposed new space technologies as promptly as possible. Of course, such examinations do not constitute a definitive schedule for the development of Shuttle-derived space utilization technologies. Rather, these analyses attempt to describe possible evolutionary paths for future space program development, based on the conclusions of contemporary NASA studies. Each of the proposed space technologies and systems is feasible within the delineated time frame. However, the degree of certainty of implementation of any given system declines in inverse proportion to the number of years and level of funding required to achieve operational status. Three possible stages of Shuttle-derived space technology development are described below.

A. The 1980s: Learning to Use the Space Transportation System

Following the successful completion of Space Shuttle test flights in mid-1982, the remainder of the decade will focus on learning to use the Shuttle's capabilities most effectively. By 1985 the Shuttle fleet will include four orbiters. In 1983 the STS will begin routine operations by transporting satellites, space probes, booster rockets, experiment facilities, and crews to and from near-Earth orbit. Specific Space Shuttle projects fall into the following areas (each discussed below): space science and astronomy, space applications and utilization, and military applications.

(1) *Space science and astronomy.* The planet's murky atmosphere inherently limits Earthbound astronomy. Spaceflight provides the capability to place into orbit sensitive new instruments that greatly augment existing knowledge of the solar system, galaxies, and high-energy objects such as quasars and pulsars. Perhaps the most dramatic advances in space-based astronomy stem from the Space Telescope, scheduled for Shuttle launch in 1986. The

The Light Ship by Attila Hejja, oil, 36" by 48".

13-meter-long (43-foot-long) telescope features a 244-centimeter (96-inch) primary mirror, accompanied by five auxiliary instruments. Flying above the atmosphere, the telescope will significantly increase both the number of astronomical objects visible for study and the distances that can be covered. Astronomers thus will be able to resolve objects five to ten times smaller in angular diameter than those subject to ground-based optical observations. Because of the interrelationships among cosmic distance, light and wave transmissions from objects in space, and time, the Space Telescope will allow astronomers to peer billions of years back in time—into the early evolution of the universe. Astronauts from the Shuttle will service the Space Telescope in orbit; however, the instrument will be returned to Earth approximately every five years for refurbishment.

Other Shuttle-based astronomical instruments that might be launched in the late 1980s include the Gamma Ray Observatory (GRO) and the Shuttle Infrared Telescope Facility (SIRTF). Gamma ray astronomy explores the highest-temperature and most explosive astrophysical objects, specifically neutron stars and possibly black holes. Gamma ray studies not only enhance knowledge of these highly energetic transmission sources, but also provide direct data on the nuclear processes of such objects—thus creating a new field of astronomy, nuclear astrophysics. SIRTF would supplement and extend current ground-based infrared studies of astronomical objects and processes such as luminous infrared galaxies, quasars, star and solar system formation, and mass exchange between stars and the interstellar medium. Through infrared observations of phenomena such as the galactic "red shift," SIRTF would contribute data important to understanding the early history of the universe and the expansion of the galaxies.

Planetary exploration during the next decade will utilize the Shuttle as a launch platform. The Jupiter orbiter/probe Galileo represents the first planned Shuttle-based planetary exploration mission. Now scheduled to arrive at Jupiter in 1989, Galileo will perform two tasks: the Galileo orbiter vehicle will conduct scientific studies of Jupiter and its satellite system from an orbital vantage point; and the probe, the first vehicle ever to enter Jupiter's atmosphere, will descend through the atmosphere, measuring and transmitting data back to the Galileo orbiter, which will relay the information to Earth. The probe should survive as long as one hour in the intense Jovian atmospheric pressure.

(2) *Space applications/utilization.* A significant segment of Shuttle missions in the 1980s will provide routine transportation for applications satellites sponsored by the U.S. government, scientific institutions, firms or industries, and other nations. For example, in its first four years of operations, the Shuttle will carry communications satellites into orbit for Canada, Indonesia, Intelsat, RCA, Saudi Arabia, Bell Telephone, and the People's Republic of China.

The new launch and repair capacities inherent in the STS probably will spur a revolution in satellite services. Existing satellite systems require large and expensive Earth receiving stations because of launch vehicle limitations on payload sizes and the inability of current launch vehicles to retrieve and/or repair satellites in orbit. The Shuttle will transform these constraints—satellites can be larger and far more complex, and ground stations can be small, portable, and inexpensive. This phenomenon, called "complexity inversion" by space engineers, could fundamentally alter the economics of space-based information services; user costs could decline dramatically, producing sizable increases in user demand. Public service satellite systems could be economically implemented (for example, a system linking paramedics and physicians assistants in remote areas with trained urban hospital staffs). Indeed, advanced satellite communication systems made economical by the Shuttle could influence humanity's lifestyles and interactions as profoundly as the advent of the telephone or television. Advanced Shuttle-delivered and Shuttle-serviced satellites could be applied to emergency rescue systems, improved aircraft traffic control, electronic mail, border surveillance, forest fire detection, earthquake prediction, nuclear materials location, and many more projects.

One advanced satellite technology certain to emerge during this period—the direct broadcast satellite (DBS)—differs fundamentally from traditional broadcast media, including extant satellite television systems. DBS eliminates the need for large and costly local reception and retransmission facilities; rather, the original signal is beamed to a DBS in geosynchronous orbit, then relayed from the satellite directly to relatively small and inexpensive dish-shaped antennas mounted on the roofs of individual homes. Each DBS services homes within a wide geographic area. The Communications Satellite Corporation (Comsat) intends to offer a three-channel DBS system to millions of home subscribers in the mid-1980s. A study by RCA Americom predicts that as many as fifty-two DBS orbital satellites will be launched in the 1980s. DBS advocates envision a direct broadcasting system that will extend television service to remote areas not now served, as well as significantly expand viewing options by fostering alternative programming.

Beyond the transmission and provision of data, satellites have proved quite useful in detecting and mapping renewable and nonrenewable Earth resources. NASA's Landsat satellite series provides multispectral images of global resources for a variety of national and international users. The Landsat series originally relied on three satellites launched in 1972, 1975, and 1978 (all now virtually inoperable). A fourth satellite, Landsat 4, was launched by a Delta rocket in 1982, and Landsat D' is scheduled for Shuttle launch in 1986.

These new Landsat satellites will mark an important shift in the focus of the program. To date, NASA has classified the system as experimental. In contrast to the communications satellite industry, a mature market with estimated gross expenditures of $11 billion annually, Earth sensing is not yet a fully operational service. Demand for Landsat imagery has outstripped the existing system's designed capability in terms of quantity, quality, and timeliness of data. State and local governments use Landsat

imagery for a variety of purposes, such as mapping land use patterns, managing state lands, and monitoring environmental pollution. National governments rely on the images for numerous functions, including crop forecasts, water resource use analyses, and overall resource assessments. Individual companies also employ Landsat data, for example, in oil and mineral exploration and new factory siting decisions. Landsats 4 and D' will constitute the basis for the operational system, carrying the latest in Earth-sensing technology. Data will be recovered via NASA's Tracking and Data Relay Satellites (TDRS), a system of Shuttle-launched orbiting data relay satellites scheduled to be operational by 1984. Landsats 4 and D' have been turned over to the Department of Commerce for operational management—and perhaps ultimately transferred to private sector control.

Additional remote sensing satellites may be deployed by the Shuttle in the 1980s. Candidate systems include a stereoscopic satellite which is particularly useful in oil and mineral exploration and a synthetic aperture radar device which can observe the oceans and obtain a variety of data on sea surface conditions.

The development of space industrial applications represents one of the more important long-range benefits of the Space Shuttle. Studies conducted on small sounding rockets, in the Skylab orbital workshop, in ground-based materials laboratories, and by Soviet cosmonauts on the Salyut Space Station suggest that the microgravity and vacuum characteristics of space may offer several advantages over ground-based methodologies in the processing of metals, fluids, crystals, and living cells. For example, the microgravity conditions would dramatically reduce convection during melting and solidification; convection currently prevents Earthbound scientists from producing a truly homogeneous material.

Spacelab, a joint project between NASA and the European Space Agency (ESA), may play a vital role in demonstrating the viability of space industrialization. Spacelab is a modular "shirtsleeve" laboratory that will go into space in the Shuttle cargo bay and return to Earth at the end of the flight. This self-contained facility affords scientists the opportunity to conduct science and applications experiments in the near zero-gravity conditions of Earth orbit. Ten European nations financed the development of Spacelab, which more than forty European companies produced under ESA contracts. ESA provided the first Spacelab (including test and ground equipment), which may be flown on the Shuttle as many as fifty times during its ten-year lifespan. Both NASA and ESA will develop experiments and train mission specialists for the orbiting laboratory. The U.S. will purchase from ESA any additional Spacelab modules required by the STS user community. In February 1980, the United States agreed to purchase a second module for 1984 delivery.

Depending on mission requirements, Spacelab can incorporate one or two pressurized cylinders (each four meters wide by two and three-quarters meters long, or thirteen feet wide by nine feet long); each cylinder can both accommodate one to four mission specialists (who can conduct a variety of tasks and scientific experiments) and include as many as five external pallets. The pallets serve as platforms for mounted experiments that require exposure to the space environment (Spacelab functions with the orbiter's cargo bay doors open). Moreover, Spacelab pallets cool equipment and generate electricity for the experiments. Typical pallet-mounted experiments include telescopes and antennas. In some mission configurations, the pallets are used without the pressurized cylinders and are controlled from the orbiter main cabin.

In many ways, Spacelab serves as a model for a free-flying space station such as the proposed Space Operations Center (described in a subsequent section). The pressurized module contains lights, electrical outlets, work spaces, storage facilities, an airlock, and an optical window. Available experimental facilities also include telescopes for several wavelengths, furnaces, high-energy lasers, microscopes, centrifuges, and incubators. Many of the candidate missions build directly on experience acquired from Skylab, an earlier space station derived from Apollo-era technology.

Candidate Spacelab missions reflect the scope of potential uses of the Shuttle-provided space environment. Scheduled for the fall of 1983, the first mission will carry thirty-five experiments (twenty-one from ESA, fourteen from NASA) for seventy-two separate investigations in the fields of medicine, plasma physics, atmospheric physics, Earth observations, astronomy, solar physics, life sciences, and materials science. Subsequent missions may emphasize certain themes, for example, the "Earth viewing application laboratory," which will conduct a world crop survey, assess global mineral deposits, inventory water resources, study weather and climate, supply data for urban planning, and investigate the oceans. Other theme missions might focus on astronomical research, advanced technology experiments (which examine the behavior of materials in the microgravity and vacuum conditions of orbit). Spacelab also will be available for rental to users who want to conduct experiments of their own design for possible commercial applications.

One of the earliest attempts to commercially exploit the Shuttle will be an apparatus that will perform a continuous-flow electrophoresis process which will separate biological materials. McDonnell Douglas Corporation is building the apparatus under a joint endeavor agreement with NASA. If the initial 204-kilogram (450-pound) device successfully produces ultrapure pharmaceutical products (such as vaccines and serums) during a six-flight test sequence, McDonnell Douglas and the Johnson & Johnson Company subsequently will launch a 4,535-kilogram (10,000-pound) long-term system to be deployed in orbit for continual production.

One of the earliest electrophoresis products may be urokinase—an enzyme that can be separated from human kidney cells and will dissolve blood clots. Current urokinase production costs in Earth laboratories are prohibitive—a single dose can cost $1,500. An experiment conducted in 1975 on the joint U.S.A./U.S.S.R. Apollo-Soyuz space mission successfully separated the enzyme from the kidney cell cultures at six times the efficiency achieved to date on Earth. One analysis suggests that full-scale production of

urokinase on the Shuttle or Spacelab could lower the cost to $100 per dose. Such a reduction could stimulate the use of urokinase in both research and treatment, possibly preventing as many as 50,000 blood clot deaths annually in the United States alone.

Other candidate products for space processing experiments on the Shuttle and Spacelab include electronic components (such as pure crystals for semiconductors and silicon ribbon for integrated circuits), improved turbine engine blades, and advanced optical products for laser systems. Experiments in these fields in the 1980s should do much to establish whether or not space processing will ever achieve commercial viability.

In 1980, the General Accounting Office issued a report which recommended that the United States increase funding by two to three times in order to maintain parity with other nations' efforts (particularly those of the Soviet Union, Japan, and West Germany) in space processing given its potentially enormous economic and social implications.

(3) *Military applications.* Although the Space Shuttle operates primarily as a civilian project, the Department of Defense (DoD) plans to make extensive use of the Shuttle. Military interest in and use of the space environment constituted a crucial factor in Shuttle design (at Air Force request, the cargo bay was enlarged to its current size to accommodate military payloads).

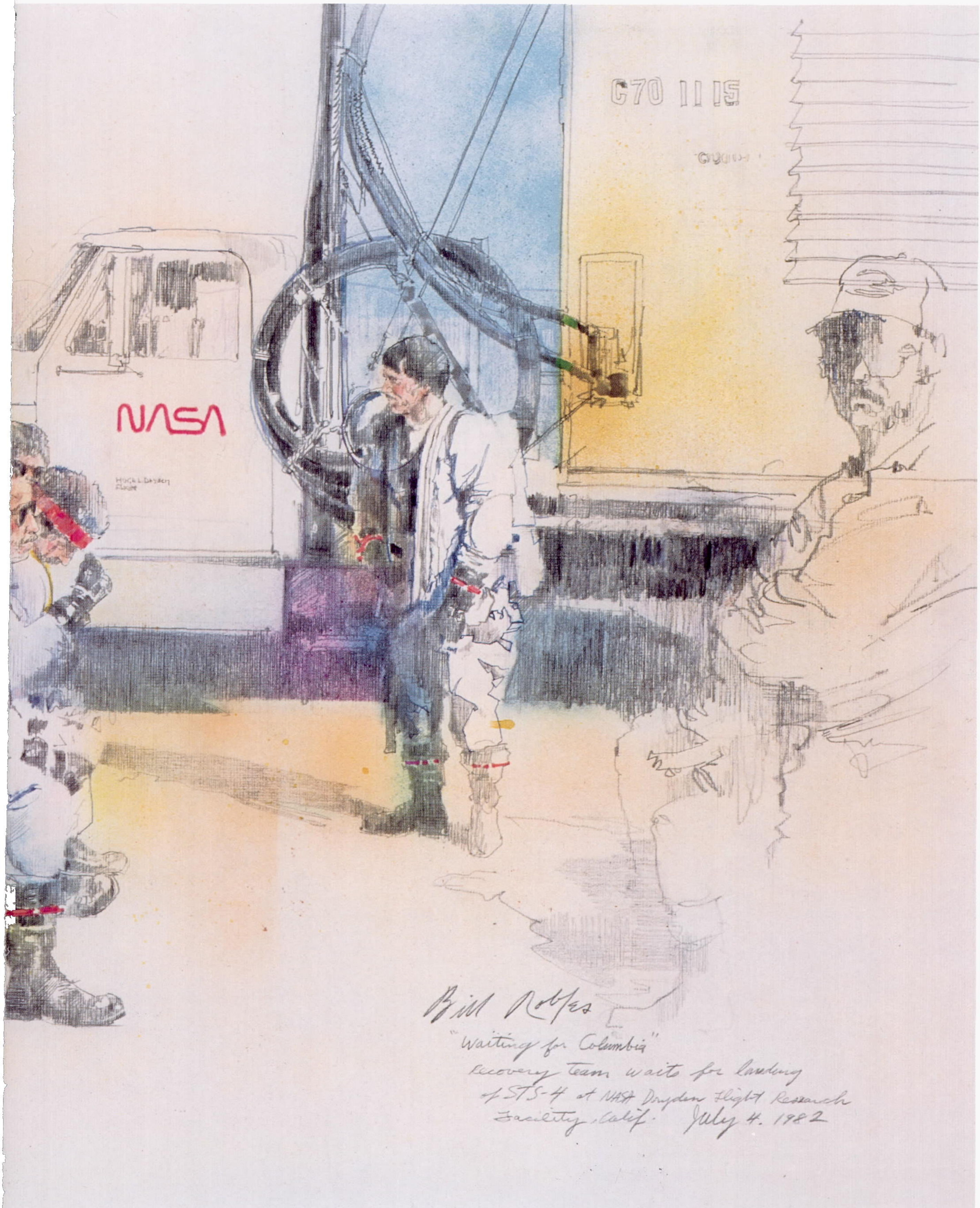
The importance of space to national security stems from many of the same attributes that make space useful for scientific and industrial purposes. Considered the "high ground" by military strategists, space already serves a critical function in information collection and distribution (for example, monitoring arms control agreements and tracking troop and weapon deployments). Moreover, the various armed services operate their own navigation, communications, weather, and surveillance satellites.

The Space Shuttle will augment greatly such military space capabilities. Although many DoD Shuttle payloads are classified, some missions probably will deploy a new generation of reconnaissance, communications, and navigation satellites. Shuttle capabilities also allow in-orbit satellite repairs and other activities such as film retrieval. Because of the Shuttle's large payload capacity, satellite design parameters can be altered substantially. Military satellites can be larger and less expensive, incorporate additional systems for redundancy, and claim a longer life span.

DoD also is considering the military utilization of Spacelab. Potential military Spacelab missions include: (a) basic scientific research—for example, the impact of solar physics on communications and navigation; (b) long-term exposure to the space environment—military space systems require a high degree of survivability; and (c) materials processing in space—for example, high-purity crystals for semiconductor elements.

To date, military space systems have exclusively supported defense and military activities on Earth. As both the civil and military communities increasingly rely on space technologies in the future, some observers project a new role for military space systems—i.e., defense of space assets. Of course, international treaties prohibit

Waiting for Columbia by Bill Robles, mixed media, 20" by 26".


NASA
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Bill Robles
"Waiting for Columbia"
Recovery team waits for landing
of STS-4 at NASA Dryden Flight Research
Facility, Calif. July 4. 1982

weapons of mass destruction in space; nonetheless, military researchers study space weaponry such as antisatellite devices and space-based laser antiballistic missile systems. Although DoD has not clarified the Shuttle's role in the development of these systems, the vehicle does constitute an invaluable system for military uses. Furthermore, experimentation on board the Shuttle in the 1980s likely will identify a large number of new applications for subsequent military space systems.

B. The 1990s: Moving Toward Permanent Space Facilities

By the late 1980s, STS should be a mature technological system, an integral component of an expanding national and international economy, and an important tool for new scientific experimentation and discovery. To ensure the continued orderly development of U.S. space capabilities, a new technological goal for NASA probably will be established, focusing on an evolutionary follow-on to the STS (in addition to ongoing space science and application projects). The next logical new goal for the NASA budget in the mid-1980s may well be a program to achieve permanent occupancy of space by the early 1990s.[1]

A national commitment to the permanent occupancy of near-Earth space will address a number of needs, including: (1) user requirements for: additional orbital stay time; increased electrical power; and facilities for servicing payloads, deploying spacecraft to geosynchronous orbit, and conducting long-term, human-tended experiments; (2) the national objective of establishing a secure base for military and civilian activities; and (3) federal requirements to provide for the continual and orderly development of future space technologies by defining an ongoing goal, thus helping to maintain the nation's overall technological base. Several technological bases of permanent occupancy of space are discussed briefly below.

(1) *Space platforms.* The Shuttle's large capacity and relatively low cost should encourage the aggregation of satellite experiments and applications into larger, multipurpose orbiting facilities. In contrast to separate spacecraft for each experiment or application, space platforms will accommodate many projects simultaneously and produce major economic savings in spacecraft design and construction. Space platforms will provide electrical power, attitude control, and communication services for all aspects of experiments and applications.

These unstaffed platforms will be placed in a variety of orbital inclinations and altitudes, including geosynchronous orbit. However, space platforms in geosynchronous orbit would require a low-orbit staffed space station and orbital transfer vehicles to both build and service the platform. The Shuttle will directly service space platforms in low orbit.

(2) *Space stations.* The cornerstone of a program for permanent space occupancy is a constantly staffed space station (or a number of space stations) which can support a variety of scientific, applications, construction, and orbital support missions.

NASA planners believe that orbital space stations may be based on one or both of two approaches. In one scenario, NASA would employ an evolutionary approach to augment unstaffed space platforms by adding one or more habitation modules, thus providing the necessary infrastructure for permanent low-Earth science and applications platforms (SAMSP). These facilities would serve principally as scientific research and surveillance stations for both military and civil purposes. Low-Earth polar orbits for crew-occupied platforms would be ideal for Earth resources surveys and/or military surveillance missions. Higher altitude equatorial orbits would seem more convenient for long-term scientific studies. However, polar orbit stations would not service spacecraft and facilities bound for geosynchronous orbit.

NASA also is studying the advantages of a Space Operations Center (SOC)—incrementally built and staffed by a permanent crew—that would serve as an orbital way station between Earth and geosynchronous orbit or deep space. In addition to SAMSP's advantages for research and surveillance, NASA engineers contend that the SOC would facilitate: (a) construction, checkout, and transfer to operational orbit of large, complex space systems; (b) on-orbit assembly, launch, recovery, and servicing of staffed and automated spacecraft; (c) management of co-orbiting free-flying satellites; and (d) development of the capability for permanent human operations in space with reduced dependence on Earth for control and resupply.

The SOC would play a primary role by permitting routine access to geosynchronous orbit by Shuttle payloads and large structures such as advanced communications satellites. Cargo would be off-loaded at the SOC and shifted to orbital transfer vehicles for transport to geosynchronous orbit.

NASA envisions building the SOC from modules and aggregates transported to orbit by the Shuttle for assembly. The SOC would include two service modules, each providing: electrical power, generated by two large solar arrays; guidance, control, and stabilization; reaction control; communications; and airlocks for extravehicular activity. Two habitation modules would be attached to the service module; each habitation unit would operate: a command center capable of controlling the entire station; private quarters for four; food, hygiene, and waste management facilities; and exercise and recreation equipment. One habitation module would contain a health maintenance facility, the other a small laboratory.

(3) *Orbital support and advanced transportation.* To fully realize the potential of automated low-orbit platforms, geosynchronous platforms, and space stations, NASA requires further advances in orbital support and transportation systems. Typical support system components include an advanced maneuvering unit to enable astronauts to perform extravehicular activities. Worn over space suit life support systems, the maneuvering units generate propulsion thrust by venting compressed gas through a system of nozzles. "Cherry picker" mobile maneuvering units (both open and closed cab types) and teleoperator maneuvering devices represent other possible support systems. These types of support system devices would assemble space structures and service spacecraft.

Transport of materials and supplies to geosynchronous orbit requires the development of new Shuttle-derived vehicle technologies, such as a reusable orbital transfer vehicle (OTV). The OTV would travel from the SOC to high-energy orbits and then return to the SOC (initially transporting payloads, subsequently flight crews).

The Shuttle-derived cargo vehicle (SDCV) constitutes another important space transportation system. Many missions planned for the late 1990s likely will require both much greater lifting capacity than the Space Shuttle presently generates and significantly lower launch costs than those currently available. For example, in one SDCV concept, the orbiter would be replaced by a large, automated payload package attached to the orbiter's main propulsion system, i.e., the standard external tank and solid rocket boosters (SRBs). This configuration would place a 68,000-kilogram (149,900-pound) payload into low-Earth orbit. Replacing the SRBs with liquid-fueled boosters and other modifications would uprate the vehicle's payload capacity to as much as 160,000 kilograms (352,700-pounds) to low-Earth orbit. In another concept, only the Shuttle SRBs would be used in one of several possible configurations to increase payload launch capability.

The solar electric propulsion system (SEPS) might serve as another transport vehicle for the 1990s. SEPS would produce thrust by electrically charging a vapor of an element such as mercury and then accelerating that vapor through an electric field. Although SEPS would generate very low thrust, the power would be continuous over a period of several months and gradually would accelerate a payload to extremely high velocities. NASA conducted orbital tests of SEPS engines on experimental satellites for many years with great success. (However, further development of SEPS currently is suspended.)

Thus, with these program elements—automated space platforms, staffed space stations, and orbital support and advanced space transportation technologies—the U.S. can establish a permanent presence in near-Earth space early in the 1990s. Such a presence should enable an entirely new generation of space technologies to service expanding economic, scientific, and social needs on Earth and in space. Some of these technologies and their applications are described below.

(4) *Space technologies and applications.* The Shuttle can enhance capabilities to construct large space structures for low-Earth and geosynchronous orbit applications in space sciences and astronomy. But the Shuttle also can facilitate the construction of devices and large structures targeted at fundamental advances in space-based astronomy and astrophysics. A recent NASA-sponsored study described one such potential system, a pair of wideband Michaelson interferometers. Such an optical system could:

> . . . detect an Earth-sized planet in orbit about a star thirty-two light-years away, calibrate the distance scale of the universe by measuring directly the distances and luminosities of the Cepheid variables, measure the proper motion of stars in our own and neighboring galaxies, and observe the second-order relativistic deflection of starlight by the Sun.[2]

The same study detailed laser instruments that would detect gravity waves generated by the collapse of stars and by the formation of black holes.

Other candidate astronomy and astrophysics technologies for the 1990s include: (a) a large X-ray telescope to measure spectra from celestial sources; (b) a 10,000-kilogram solar observatory to make high-resolution spatial, spectral, and time measurements across all light wavelengths for advanced studies of the Sun; and (c) a large-scale microwave telescope to conduct very advanced radio astronomy experiments and perhaps search for radio waves emitted by extraterrestrial civilizations.

In planetary research, the initial reconnaissance of this solar system should be nearly completed for all planets but Pluto by the 1990s. New Shuttle-based solar system exploration projects should advance this research into the 1990s. Proposed missions to the outer planets (Uranus, Neptune, and Pluto) would take advantage of Jupiter's orbital position between 1989 and 1997 to launch gravity-assisted spacecraft. Another high priority outer planet mission would employ an orbiter and probe configuration similar to Galileo to probe both Saturn's atmosphere and that of the moon Titan.

During this period, a mission to rendezvous with an asteroid could use either ballistic trajectories (chemical propulsion) or low-thrust trajectories (SEPS). Such a mission could include a landing to analyze asteroid surface composition. This asteroid reconnaissance mission could produce progress in both pure science and the exploration of the feasibility of acquiring and using asteroid materials for near-Earth space manufacturing and construction (discussed below).

Exploration of the inner planets offers similarly intriguing possibilities. Mission options include a Mercury orbiter and lander and a variety of lunar missions (e.g., a lunar polar orbiter that would map and analyze the high latitudes of the Moon). Another mission would land a spacecraft on Venus to conduct a chemical analysis of apparently one of the most complex and radioactive soil compositions in the solar system. Such a mission would be a strong candidate for a joint U.S./U.S.S.R. effort because of the Soviet Union's long-term interest in the exploration of Venus.

Perhaps the most exciting prospects for automated, Shuttle-based solar system exploration in the 1990s focus on advanced investigations of Mars. Despite a relatively substantial Mars exploration program—including the first attempt to discover extraterrestrial life—numerous unanswered questions and unresolved puzzles remain. Scientists and engineers have devised several STS-based missions, including a Mars polar orbiter, a network of scientific stations, a robot roving vehicle, an airplane explorer, and a soil sample collector.

Opportunities during the 1990s for meaningful, Shuttle-based solar system exploration likely will exceed U.S. financial and information management and analysis capabilities. However, space exploration programs of this type naturally lend themselves to international cooperative ventures. Such international cooperation would accelerate the pace of planetary exploration, but even a vigorous

international effort during the 1990s probably would overlook numerous important missions that could be scheduled for the post-2000 period.

The economic development and utilization of space systems and resources (termed space industrialization by space planners) present significant challenges and opportunities for STS and Shuttle-derived technologies during the 1990s.[3]

Several space environment characteristics suggest a host of possible applications for Shuttle-based industries, based on factors such as: (a) easy control over gravity; (b) absence of atmosphere; (c) comprehensive overviews of the Earth's surface and atmosphere; (d) isolation from Earth's biosphere (particularly relevant to hazardous processes); (e) freely available light, heat, and power; (f) infinite natural reservoirs for disposal of waste products and safe storage of radioactive products; (g) super-cold temperatures; (h) large, three-dimensional volumes (storage structures); (i) a variety of non-diffuse (directed) radiation; (j) magnetic field; and (k) availability of extraterrestrial raw materials.[4]

Beginning in the mid-1970s, NASA began to assess the potential of space industrialization in the Shuttle age. In 1977 NASA released a Rockwell International study which concluded that:

> . . . space industrialization is relevant to many urgent problems afflicting the nation and mankind. It offers important practical opportunities for strengthening our economy and provides access to new energy and material resources. It reduces the burdens on the terrestrial environment and offers new options for human growth in an open world.[5]

Together, these NASA-sponsored studies[6] constitute a technological and economic framework for projecting the pace and focus of space industrialization. Such studies thus serve as an invaluable research tool for students and teachers interested in analyzing the implications of Shuttle-derived technologies; reports have identified literally hundreds of potential space industrial opportunities. Of course, actual implementation of specific industrial systems and technologies will depend on several factors, including economic viability, competing national priorities, and social and institutional implications.

The individual systems and technologies relevant to Shuttle-based space industrialization in the 1990s seem to cluster in four broad areas: (a) information systems; (b) products manufactured in space; (c) energy generation applications; and (d) humanization. A Science Applications, Inc. study detailed the following subdivisions within the four industrial activity categories.[7]

Information Services
Communications
Earth observations
Navigation
Location determination
Sensor polling

Energy
Solar power satellites
Redirected isolation
Nuclear waste disposal
Nuclear power or breeder satellites
Power relay satellites

Products
Biologicals
Electronic components
Electrical components
Structural items
Process improvements
Opticals

People
Tourism
Medical care
Entertainment and art
Recreation
Education
Support facilities

Some of the specific technologies within these categories are considered below. These discussions should introduce the reader to the range of products and services potentially available within a program of Shuttle-based space industrialization. The actual studies provide a relatively comprehensive listing of the various relevant technologies.

Information systems. Communications and Earth-sensing satellites constituted a maturing industry in the 1980s and should develop into an advanced industry in the 1990s. For example, personal communications satellites could be operational in the early 1990s; in one scenario, a single 67-meter-diameter satellite in geosynchronous orbit could service twenty-five million people with two-way voice and data communications using wristwatch-size ground-based radio sets.[8]

Public service applications for large, multi-beam satellites are many and varied. For example, such satellites could: establish immediate communication links with rescue authorities during disasters; provide continuous, all-weather monitoring of global air and ocean traffic; improve educational services in remote areas through direct broadcast of public service programming; and facilitate remote health care services via three-dimensional teleconferencing.[9]

One public service satellite proposal would group several functions on a single, large satellite in geosynchronous orbit. This satellite would weigh 29,500 kilograms (65,035 pounds), measure 240 meters (9,449 feet) in length, generate 500 kilowatts of solar cell power, and deploy 23 antennas. The system would supply the continental United States with a broad range of services, including: (1) educational programs broadcast over five simultaneous video channels for sixteen hours each day; (2) personal voice communications; (3) national information services affording instant access to government, university, and industry data banks; (4) teleconferencing on as many as 150 simultaneous two-way video channels; and (5) electronic mail transmission at a rate of forty million pages per day.[10]

During the 1990s, Shuttle-borne Earth resource sensing satellites located in polar orbits should offer increasingly

sophisticated views of the planet that will be useful for renewable resource management. For example, advanced satellites should produce a continual, comprehensive assessment of worldwide crop production levels. Such an agricultural watch should accrue significant benefits if conducted and institutionalized to inspire international cooperation.[11] Other advanced Earth resource systems that might be functional in the 1990s include: (1) water availability forecasting; (2) living marine resources assessments; (3) timber inventories; (4) large-scale weather forecasting and climate prediction; and (5) insect monitoring and control systems.[12]

During the 1990s, hazard warning systems (particularly satellite-based earthquake prediction systems) should generate substantial interest in the field of advanced Earth sensing systems. Recently acquired scientific knowledge in geology and seismology—on topics such as plate tectonics—may provide the basis for constructing accurate earthquake forecasts. Very long baseline interferometry and laser measurements of the Earth's crustal movements should contribute significantly to the knowledge base and, subsequently, to an operational system for earthquake predictions. In this system, Shuttle-deployed satellites would reflect radio signals and laser beams to ground-based instruments on an auxiliary basis.[13] Analysts would combine the data from these subsystems with ground-based measurements from the operational system. Such an operational system would reduce risks to life, increase the ability to prepare for and respond to disasters, and lower the costs of international rescue and assistance efforts.[14]

Products manufactured in space. An inhabited space station or operations center equipped with solar power augmentation modules should facilitate greatly the development of commercial space processing, perhaps leading to the first true "space factories" in the 1990s. If successful, initial experiments aboard Shuttle and Spacelab in the 1980s should identify the viable systems and processes that hold the greatest potential for early commercial and industrial applications. One study predicts that semiconductors produced in orbit could account for ten percent of the total market ($1.27 billion) by the end of the decade.[15] Moreover, space processing and manufacturing probably will focus on numerous other products and applications, described earlier, that could prompt national and international governments and corporations to invest significant resources in the space-based economy. Such investment may spur the development of additional multipurpose or dedicated space operations centers, with attendant demands for expanded orbital transportation and support systems.

Energy generation applications. A permanent space occupancy program fundamentally would attempt to fulfill important terrestrial needs in a cost-effective manner by applying selected space technologies. The provision of adequate and economical energy supplies in an environmentally acceptable mode should continue to dominate Earth's resource and industrial requirements throughout the remainder of the century.

Space industrialization would supplement the terrestrial energy base in several ways, specifically by:

(1) Providing technology that can be used to generate and transmit energy on Earth and to dispose of waste products associated with fission power. One industry estimate suggests that producing silicon crystals in space might reduce the cost of switching from AC to DC power transmission on Earth by as much as $76.5 billion over the next twenty years.[16] NASA also is studying the prospects for STS disposal of nuclear waste material in space;[17]

(2) Stationing power reflectors in space that can passively relay electrical power from Earth-based power plants to Earth-based end users;[18] and

(3) Generating solar energy in space and transmitting it to Earth.[19] This option appears technologically and economically feasible some time in the 21st century (discussed in depth below). During this stage of STS development, initial proof-of-concept studies might be conducted in orbit.

Space humanization. Prospects for human-oriented industries in space—such as medical, clinical, and biogenetic research; space sciences; educational centers; hospitals; and the arts—may become technically viable during the latter part of the second stage of STS development.[20] These human industries would depend on the timely and step-by-step developments of the systems and subsystems (described earlier) that are necessary to implement the permanent space occupancy program.

C. 2000 and Beyond: Conducting Large-Scale Space Operations

At the outset of the 21st century, human civilization should be completing a fundamental transition period. If current projections are accurate, humanity should have a permanent presence in near-Earth orbital space. The subsequent development of new space technologies during the post-2000 period should focus on extensions and offshoots of STS; however, in many ways such developments would be as different from the Shuttle orbiter as that vehicle is from the Mercury space capsules of the 1960s. Of course, such 21st-century developments can only be described in basic terms at this time. In many instances, descriptions of future technologies are not the product of systematic NASA advanced planning, but rather of visionary space planners in industry, academia, government, and, in some cases, science fiction writing. Moreover, no attempt is made to fully assess the prospects for post-2000 space development. Instead, a range of technologies and missions are discussed in order to reflect the breadth of options available to space planners and to society as a whole.

An entire new generation of Shuttle-derived orbital transportation vehicles probably will be operational after the year 2000. Researchers have studied and advocated many candidate systems since 1960. Many of the transportation systems differ in terms of number of stages, launch attitude (vertical or horizontal), landing attitude (ballistic or lifting), and landing location (land or water).[21]

Continuing development of new Shuttle generations

Taxi-Orbiter and 747 by Tom O'Hara, acrylic, 29" by 37".

ORIGINAL PAGE
COLOR PHOTOGRAPH

is spurred by the intrinsic technological advances associated with years of orbital transport experience and by the ever present need to achieve the lowest possible per kilogram cost of transporting people and goods into space. More than one Shuttle-derived orbital transport system may be developed in this period. In one scenario, a single-stage-to-orbit, Shuttle-type craft would ferry people to orbit, while new versions of a heavy lift vehicle would provide low-cost transportation of goods and equipment.

The development of a Moon base may well constitute a significant addition to overall space operations during the 21st century. A lunar base would serve both scientific and industrial purposes. The early return missions to the Moon likely would continue the exploration process begun by the Apollo program, which sampled only six lunar locations. Other potential scientific activities for a lunar base (or bases) focus on optical and radio astronomy. The far side of the Moon represents a desirable location for radio astronomers, because the facilities would be shielded permanently from the radio noise produced by Earth activities. The lunar surface is comparable to free space as an advantageous position for telescope location, in large measure because of the absence of an atmosphere. Scientists at the Jet Propulsion Laboratory are particularly interested in the south pole of the Moon as an optical astronomy site, because the cosmic southern hemisphere is particularly rich in objects of interest to modern astronomy.[22] A lunar base also might be useful for X-ray, cosmic ray, and possibly gravity wave observations.[23]

Although scientific applications abound for a lunar base, most of the projects probably could be conducted with equal facility at an orbiting space station. Consequently, the potential of the Moon and lunar resources to promote space industrialization and development ultimately would drive the construction of a Moon base. Analyses of surface samples from Apollo missions document that lunar soil contains many of the materials required for construction of solar power satellites, orbital facilities, and even the lunar base itself. The basic constituents of lunar rock include silicon, iron, aluminum, calcium, magnesium, titanium, and oxygen.[24] Chemical engineers already are evaluating means of extracting metals from lunar rock and processing them into valuable products.[25]

The mineral resources of the Moon may be abundant, and analysts are beginning to understand the process to extract such materials. However, the extent to which these resources would be used to construct space systems depends on the economics of lifting large quantities of materials off the lunar surface. In comparison to Earth, the Moon's weak gravity field (approximately one-sixth that of Earth) constitutes a mining advantage in terms of accessibility and environmental constraints. Yet, a NASA-sponsored Rockwell International study concluded that because most large space systems (especially SPS) still would require materials from Earth—for example, carbon epoxy, carbon fiber, polyamids—"the opportunities for taking advantage of lunar gravity to obtain structural materials appear limited."[26] The Rockwell study foresaw the primary contributions of a lunar base to be supplying oxygen for interorbital propulsion and providing maintenance services for large energy structures.

Current attempts to pinpoint economical and justifiable industrial uses of the Moon during the post-2000 period are probably premature. Specific lunar industrial developments depend on a variety of factors, particularly the extent of near-Earth orbital space development in the pre-2000 period. Krafft Ehricke, a space pioneer on von Braun's Peenemunde team, wrote:

> A primary advantage of lunar industries is that they offer the option of separating production (elsewhere) from consumption (on Earth) in an industrial civilization where it becomes increasingly difficult to do both indefinitely in the same environment.[27]

Lunar bases and industries would be an integral component of post-2000 space development, because—if for no other reason—such operations open up a new resource arena for continued economic growth.

Permanent lunar facilities are contingent upon the development of efficient economic transportation between Earth and Moon, and STS can act as the basis for this system. An industrial research group at General Dynamics/Convair designed a system that would rely on the Shuttle to carry reusable "space tugs" (derived from orbital transfer vehicles).[28] The tugs would be equipped with landing legs and radar for soft landings on the Moon. This system also would incorporate two technologies that are potentially capable of reducing lunar transportation costs by facilitating the manufacture of propellants in orbit. An efficient Earth-to-Moon transportation system also requires a variety of communication satellites in both lunar and terrestrial orbits.

Actual construction of the first Moon base may borrow significantly from terrestrial experiences with scientific bases in Antarctica and industrial outposts on the Alaskan North Slope. However, from the outset a Moon base would demand a higher degree of self-sufficiency than either of these predecessors. Initially, the base would be constructed almost entirely from prefabricated materials brought from Earth, perhaps using unprocessed materials as a radiation shield.[29] Power requirements probably would be satisfied from some combination of nuclear fission and solar energy. The high costs of Earth resupply operations would tend to place a premium on recycling various liquids, gases, and solids. Eventually, some percentage of required foodstuffs would be grown in processed lunar soils in a pressurized greenhouse.

The long-range prospects for solar system exploration continue to rely for the most part on robot probes. By the year 2000, initial fly-by reconnaissance of most of the objects of interest within the solar system should be completed. Orbital surveys and landers may be in place around and on many of the planets and several of their moons. Robot probes may conduct advanced analysis and resource mapping of some objects, providing new insights into the origin and evolution of the solar system.

The post-2000 period also may fulfill one of mankind's oldest and most enduring spaceflight goals—a visit to Mars by humans. In 1953, Dr. Wernher von Braun published a manuscript describing a detailed plan for sending astronauts to Mars.[30] Dr. von Braun's proposed

Last Test by James Dean, watercolor, 30¾" by 11½".

expedition included a flotilla of ten vessels assembled in Earth orbit, each staffed by seventy astronauts; the expedition would consume almost three years, with fifty people spending a total of 400 days on Mars. In 1970, NASA outlined a proposed mission to Mars which would begin in 1987 and use two nuclear-powered rockets to carry twelve men and two landing craft on a 600-day mission to the red planet.[31] Although NASA has not authorized additional formal assessments of manned Mars missions since the 1970 study, some aerospace experts continue to plan for a Martian mission with the STS as an integral component. British aerospace authority Dr. R.C. Parkinson proposes a mission incorporating adaptations of the Shuttle, an advanced orbital transfer vehicle, Spacelab modules, and a lander module based on the Apollo program lunar module.[32] Once on the planet, astronauts would have twenty-five days to conduct detailed explorations and scientific experiments before returning to Earth.

The barriers to mounting a full-scale Martian expedition always have included the sophistication of available technology, the project's economic feasibility vis-a-vis competing national priorities, and the political implications of such a decision. According to some experts, by the 21st century the necessary technology should be in place or readily available. Moreover, some analysts believe that the basic hardware required for the actual mission—excluding space technologies that would be developed independently (for example, an orbital transfer vehicle)—would cost substantially less than the Apollo program of the 1960s.[33] The political feasibility of such a Mars mission is very much a function of the highly variable overall national and international political climate. President Kennedy affirmed the U.S. commitment to land a man on the Moon within a decade barely four months after a contrary decision made at the highest levels of government.[34] At some point in the 21st century, the political milieu may favor a new Apollo-type commitment to a manned Martian expedition.

One of the most interesting and far-reaching proposals for the large-scale utilization of space resources suggests locating as many as sixty satellites (each approximately one-half the size of Manhattan Island) in geosynchronous orbit for the purpose of relaying large quantities of solar energy to Earth. Plans for such solar power satellites (SPS) include numerous variations in design, size, location, method of energy transmission, and even construction materials; however, the basic concept of the proposed SPS attempts to capitalize on several space-related advantages over Earth-based energy systems, for example:

(1) A satellite in geosynchronous orbit is exposed to between four and eleven times the solar energy that strikes Earth sites receiving copious sunshine.

(2) In space, solar energy is available almost continuously; only one percent of solar rays are obscured by Earth shadowing. On Earth, clouds and nightfall prevent continuous exposure of solar energy collectors to the Sun.

(3) The space environment, zero gravity, and the absence of wind and rain allow SPS to be built of relatively light materials and to be large in area without incurring the high cost of such structures on Earth.

(4) The environmental effects of such a system are thought to be within acceptable limits.[35]

Dr. Peter E. Glaser first proposed SPS in 1968.[36] Since then numerous studies failed to identify any insurmountable technological hurdles which would prevent SPS construction at some future time.[37] As with all advanced space systems and technologies, proceeding from paper studies to actual hardware production requires more than a demonstration of technological feasibility. Attendant questions of economic, social, and political viability must be addressed and resolved. A recent study by the National Research Council concluded that although there currently are no known technological barriers to SPS, economic and logistic issues may relegate the concept to the post-2000 time frame.[38]

If the preceding stage of space development—i.e., permanent space stations, large solar power modules for in-orbit use, geosynchronous space platforms, advanced Shuttle-derived heavy lift vehicles, and new orbital transfer vehicles—is completed by the turn of the century, the next major space goal may well be the provision of nearly unlimited quantities of SPS energy for use on Earth. Once the infrastructure required for orbital construction and manufacturing is well established, the cost of such a program might be reduced substantially.

The prospects for SPS depend heavily on the pace of development for competing Earth-based energy alternatives, such as nuclear fission and fusion, fossil fuels, and terrestrial solar energy. Moreover, the environmental and social implications of all potential energy systems must be evaluated. In the long term, SPS may represent the optimal mix of renewability, environmental acceptability, and economic feasibility for a permanent source of electrical energy for Earth.

Another proposal to utilize space resources advocates the use of nonterrestrial mineral resources in the construction of many of the advanced space systems and technologies already discussed.[39] Some experts even foresee a time when the mineral resources of the solar system (especially the Moon and the asteroids) are transported to the Earth's surface in large quantities to replace depleted supplies of valuable commodities such as copper, nickel, and iron.[40]

The space program and astronomical discoveries to date document the vastness of the mineral resources of the solar system. Analyzing asteroidal spectral data, one research team determined that a single asteroid's gross economic value could total as much as $5 trillion, with the nickel content providing a millenia's supply at present terrestrial consumption rates.[41] Although these figures are admittedly simplistic, they do indicate the potential inherent in mining the mineral resources of the solar system for use in space and, eventually, on Earth as well.

Preliminary studies concentrated largely on procedures for mining and processing lunar materials and have done much to establish the technological feasibility of such systems in the long run. A limited number of studies suggest that nonterrestrial materials may offer distinct economic advantages in the construction of space manufacturing centers and solar power satellites.[42]

Clearly the future uses of space probably will be limited not by technical feasibility, but rather by societal budgetary constraints. A recent NASA study group recognized that:

> . . . the cost of space operations, even if transportation came free, makes many intriguing large scale enterprises so expensive that they will not likely gain approval in any foreseeable environment. [The study group sought to] see if such projects would become more practical through machines which use the energy and material resources available in space to reproduce themselves, creating a quickly increasing number of identical self-replicating factories that then would produce the finished machinery or product.[43]

Such a concept (labelled telefactors by the study group) offers the possibility that large-scale space projects may at some time become essentially self-financing after the initial investments in a self-replicating system. The study group considered this revolutionary concept to be both theoretically and technically feasible, although the group noted that "such systems for space use would come as the end product of a long process of developing automation, robotics, and machine intelligence."[44]

Of course, such a system raises numerous social and economic implications. Indeed, the mere fact that scientists already can suggest the initial parameters of a self-replicating machine capable of large-scale space manufacturing and production emphasizes the necessity of conducting comprehensive social analyses of proposed space systems well in advance of actual decisions to implement such technologies. The future pace and direction of the space program probably will not be limited solely by technological and economical feasibility. The social science community should provide sound and relevant data to be incorporated into the design and operation of space systems.

Appendix One supplies information on obtaining supplemental teaching materials relevant to space technologies.

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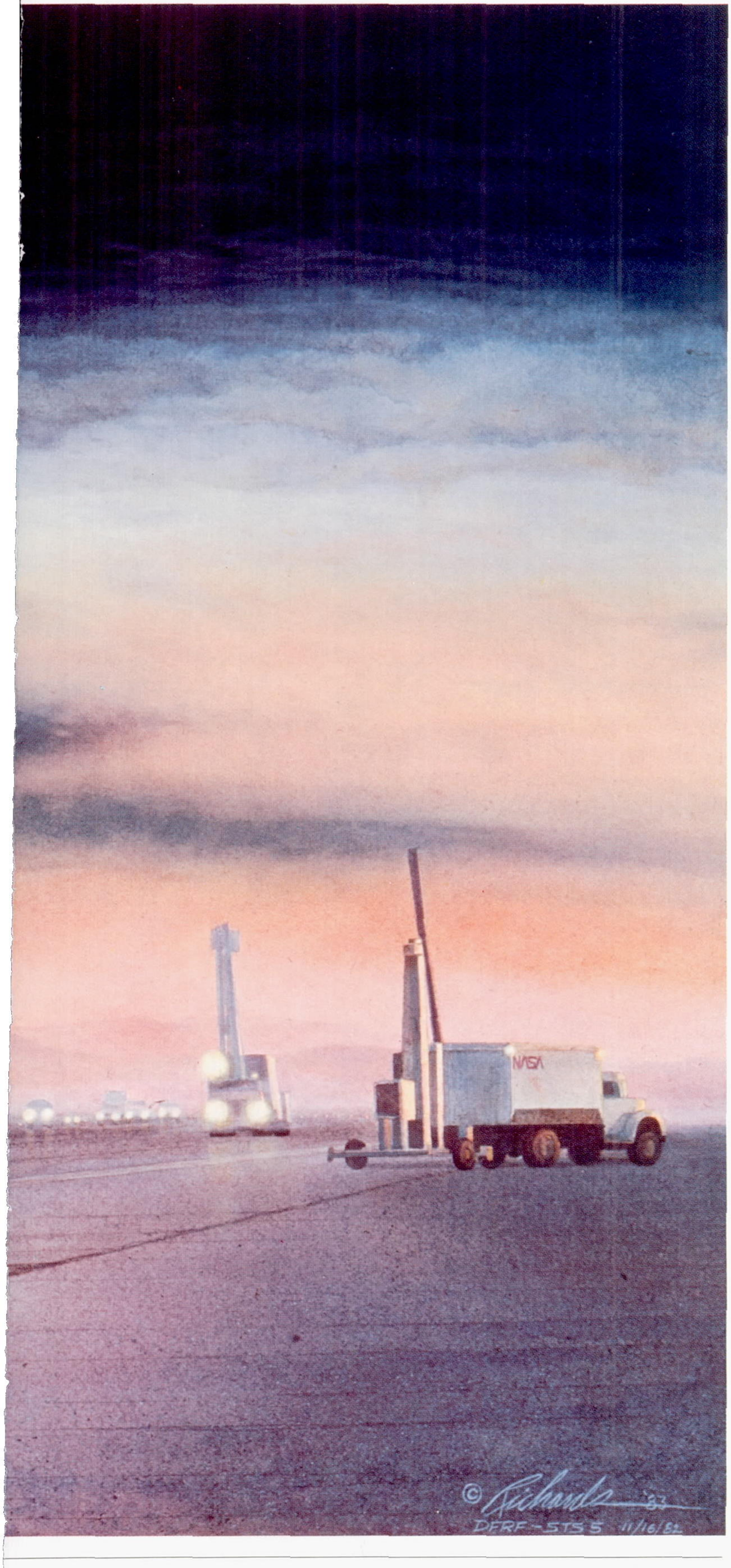
The Final Escort by Linda R. Richards, acrylic, 22″ by 30″.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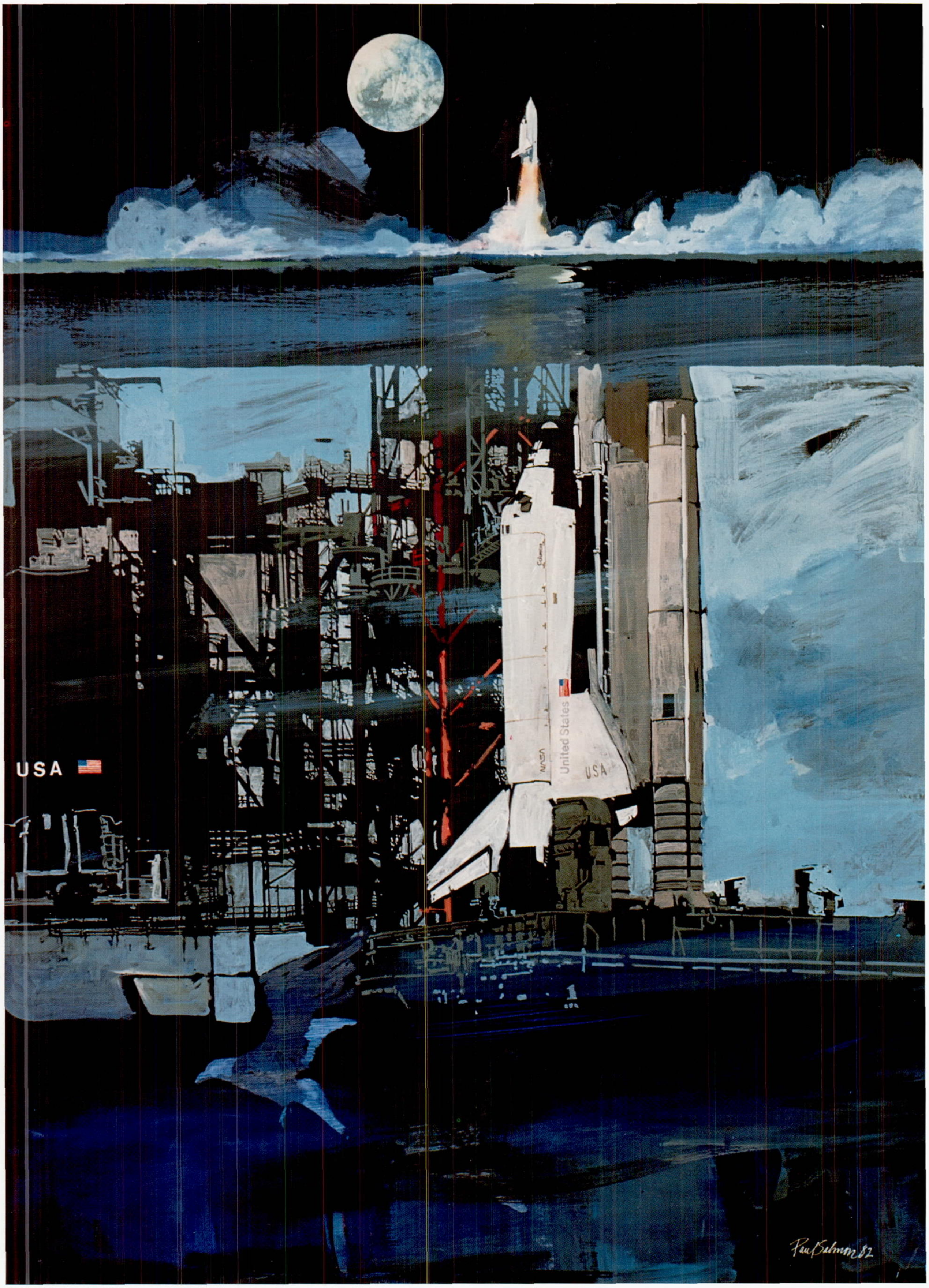

On the Pad and Launch by Paul Salmon, acrylic, 50″ by 36″

Chapter Two

Perspectives on Individual Disciplines

This chapter is divided into sections corresponding to a variety of individual social science and humanities disciplines. This organization allows faculty, students, and researchers in particular fields to address Shuttle and other space technologies within a disciplinary context. Some papers provide brief introductory materials for beginning students and other interested individuals who may not be familiar with the general role or structure of the discipline. Faculty and other readers with advanced knowledge will tend to skip such introductions.

Users of this book undoubtedly will adapt the papers in this chapter in a variety of ways that will vary according to the institutional setting. That is, some faculty may offer a course devoted exclusively to space-related issues, while others (probably the more common case) may integrate discussions of space technologies into general survey courses, employing one or more lectures that focus on the relation between space development and the specific discipline and also allow student term papers on space-related topics. The papers in this chapter are designed to assist instructors in either case, but the exact form and method of adaptation and integration of these materials depends primarily on the creative handling of the information by the instructor. Course syllabi and other supplementary materials in the appendices provide useful insights and references for instructors designing or revising courses that emphasize the interrelationships among individual disciplines, Shuttle-related technologies, and space development.

This chapter does not attempt to encompass all social science and humanities disciplines, but a broad range of representative fields are covered. As noted in the preface, stringent page constraints and the availability of appropriate materials exerted a strong influence on the selection of disciplines included in this chapter. Because the papers and appendices are individually authored, these materials reflect natural variation in form and style. Although the editors selectively revised the original manuscripts, they opted to maintain the individuality of the papers rather than to homogenize the submissions into a completely consistent format and style. Therefore, the editors assume complete responsibility for any discontinuities within the chapter.

Economics

The Economic Impacts of the U.S. Space Program

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Under Construction, Launch Pad 39B Study II by Maria Epes, oil pastels, 19" by 26

I. Introduction

Economics analyzes the production, distribution, and use of material goods and services. Economics thus focuses on the activities of the millions of business concerns, farms, workers, and households that produced and consumed almost $3 trillion worth of output in the United States in 1980. As Adam Smith said, economics is "an inquiry into the nature and cause of the wealth of nations."

The Gross National Product (GNP) measures the total output of all production units in the economy. GNP aggregates the productive activity in a particular country during a certain period of time. GNP represents the best single answer to the question, "What did we produce in the United States in 1980?"[1]

NASA's budget totaled less than 1 percent of the GNP during peak activity years in the last half of the 1960s. Why then have economists devoted considerable attention to a governmental program that represents a negligible proportion of national economic activity? Professional interest in space program economics is attributable to a growing awareness of the economic significance of technological change. Economists define technological

change as an advance in industrial-related knowledge that permits, and is often embodied in, new methods of production, new designs for existing products, and entirely new products and services.[2] Economists view technological changes as one of the most significant determinants of the shape and direction of the U.S. economy.

Technological change exerts a particularly important influence on the national rate of economic growth. A number of studies conclude that about 90 percent of the long-term increase in output per capita in the U.S. has been attributable to technological change, increasing educational achievement, and other factors not directly associated with increases in the quantity of labor and capital. The results of such studies are rough, but they do confirm the substantial effects of technological advances.

Technological change has spurred the growth of new industries and altered the competitive balance within industries. A successful new product or process can transform a firm into an industry leader. In contrast, less innovative firms may suffer economic setbacks or, in the extreme, bankruptcy. As more and more firms have recognized the importance of technological progress, outlays on research and development have increased at a rapid rate. In fact, the expansion of industrial research and development ranks as one of the most dramatic economic developments of the last three decades.

Because the U.S. government traditionally has financed a large proportion of the nation's research and development (R&D), federal programs have played a vital role in promoting technological change. The Department of Defense typically accounted for 50 percent or more of all federal R&D expenditures, while NASA and the Atomic Energy Commission ranked as the second and third largest spenders. In some years, these three agencies financed almost 90 percent of federal R&D expenditures.

This technological component of the U.S. space program attracts the interest of economists, because they believe that federal R&D spending generates more powerful economic impacts than governmental purchases of other goods and services. Consequently, the effects of space program expenditures have been the subject of several studies.

Since its inception, NASA has supported a variety of impact studies of the space program. By sponsoring such reviews, NASA has fulfilled the mandate of the 1958 National Aeronautics and Space Act, which directed NASA to conduct long-range studies of the potential benefits arising from the utilization of aeronautical and space activities for peaceful and scientific purposes. NASA-supported studies have examined the economic, technological, scientific, management, and social impacts of the U.S. space program.

This paper concentrates on: the relation between space program expenditures and economic growth; NASA's impact on the total U.S. economy and the local communities; the effect of the space program on industries; and a case study of NASA's economic impact.

II. NASA's Influence on the U.S. Economy

Analyses of the macroeconomic effects of the U.S. space program attempt to identify and measure that portion of economic growth attributable to technological progress. A Midwest Research Institute (MRI) study of the relationship between R&D expenditures and technology-induced increases in GNP indicated that each dollar spent on R&D returns an average of slightly over seven dollars in GNP over an eighteen-year period following the expenditure.[3] Assuming that NASA's R&D expenditures produce the same economic payoff as the average R&D expenditure, MRI concluded that the $25 billion (1958) spent on civilian space R&D during the 1959-69 period returned $52 billion through 1970 and will continue to stimulate benefits through 1987, for a total gain of $181 billion.

Chase Econometric Associates conducted a second econometric investigation of the relationship between NASA expenditures and the U.S. economy.[4] The first phase of the Chase study employed the 185 interindustry input-output model developed at the University of Maryland to analyze the short-run economic impact of NASA R&D expenditures. Simulations of the input-output model were undertaken assuming that $1 billion of federal expenditure was transferred (proportionately) from other nondefense programs to NASA with no change in the size of the federal budget. Chase estimated that the $1 billion transfer would increase manufacturing output in 1975 by 0.1 percent, or $153 billion (measured in 1971 dollars), and would increase 1975 manufacturing employment by 20,000 workers.

The second phase of the Chase study considered the long-run effects of NASA R&D expenditures. Using a production function which related NASA R&D expenditures to the productivity growth rate in the U.S. economy from 1960 to 1974, Chase concluded that society's rate of return on NASA R&D expenditures was 43 percent (MRI's estimated social rate of return was 33 percent). The Chase second phase also estimated the effects of changes in NASA R&D expenditures on economic growth and stability. Overall, these long-term estimates confirmed the significant positive effects of NASA R&D expenditures on national productivity and employment levels.

The Space Division of Rockwell International conducted a third study of the macroeconomic impact of NASA R&D programs. Rockwell investigated the relationship between NASA's Space Shuttle program and employment in the state of California.[5] Using an econometric model developed at UCLA, Rockwell estimated that the Space Shuttle program generated an employment multiplier of 2.8; that is, direct Shuttle employment of 95,300 man-years in California produced an increase of 266,000 man-years in total employment.

In each of the econometric studies the investigators qualified their conclusions by noting several conceptual and data limitations associated with an aggregate quantification of the returns to the economy of R&D investment. A major limitation of all three studies is the assumption that each dollar of NASA R&D spending—

whether spent on basic research or development—is equal.

III. NASA's Influence on Local Communities in the 1960s

The acceleration of manned spaceflight programs, which began in 1961, prompted both a significant expansion of existing federal facilities in Florida and Alabama and the establishment of three entirely new NASA facilities in Mississippi, Louisiana, and Texas. In the early 1960s, NASA organized the Marshall Space Flight Center in Huntsville, Alabama; the John F. Kennedy Space Center in Brevard County, Florida; the Manned Spacecraft Center in Houston, Texas; the Michoud Facility in New Orleans, Louisiana; and the Mississippi Test Facility in Hancock County, Mississippi. Because NASA's manned spaceflight activities have been concentrated in a "southern crescent" along the Gulf of Mexico, the space program has had an important influence on this region.[6]

The significance of space employment varied greatly among the five manned spaceflight communities; NASA's share of local employment was far greater in Hancock County (Mississippi), Brevard County (Florida), and Huntsville (Alabama), in that order, than in either Houston or New Orleans. Specifically, NASA Civil Service and contractor employment comprised 57 percent of total 1966 employment in Hancock County, 22 percent in Brevard County, 17 percent in Huntsville, 3 percent in New Orleans, and less than 2 percent in Houston.

In those areas where NASA accounted for a large proportion of local employment, the economic impacts of the space program were direct and identifiable. Hancock County, Brevard County, and Huntsville each experienced large increases in sales volumes of local business establishments and growth in per capita income. Between 1960 and 1965, average increases for the three communities in retail sales volume and per capita income were, respectively, 39 percent and 86 percent.

A comparison of NASA's economic impacts on Houston with those on New Orleans illustrates that the economic effect of the space program varied inversely with the strength of the local economy at the inception of the program. For example, Houston and New Orleans represented strikingly dissimilar economic environments prior to the NASA buildup. Houston had sustained a very high employment growth rate since 1940. The annual growth rate during the 1950s was 4.2 percent, compared to a national rate of employment growth of 2.2 percent. In contrast, the annual rate of employment growth in New Orleans during the 1950s was 1.7 percent. The 1957-58 economic recession produced a much more severe reaction in New Orleans. Unlike the rest of the nation, which recovered from the 1957-58 recession by 1959, total employment in New Orleans did not regain its 1957 peak of about 292,000 until 1963.

Between 1961 and 1966, employment at both the Michoud Assembly Facility (New Orleans) and the Manned Spacecraft Center (Houston) increased by about 11,000 personnel. Although the rises in employment were roughly similar, the economic impact on the depressed New Orleans economy was far greater: following an increase in the unemployment rate from 2.7 percent in 1957 to 6.2 percent in 1961, New Orleans recouped to become one of the ten fastest-growing cities in the nation between 1961 and 1966. Space-related employment directly accounted for 17 percent of the total increase in wage and salary employment during this period. However, NASA employment was directly responsible for only 10 percent of total employment growth in Houston between 1961 and 1966. Houston benefited relatively less from space employment than New Orleans; specifically, employment growth was 40 percent higher because of the influence of the NASA space program (the comparable figure for New Orleans was 60 percent).

In addition to direct economic impacts, the space program altered the quality and context of the local environment in the southern crescent. The influx of large numbers of scientists, engineers, and other professional personnel to these small cities stimulated an expansion of university and graduate programs. As an illustration, enrollment at the Huntsville Center of the University of Alabama grew from 1,500 in 1958 to more than 4,000 in the mid-1960s. The educational impact of federal R&D programs was not limited to the university and junior college level; primary and secondary school systems also improved noticeably. Rapid growth in school enrollments and construction were accompanied by substantial advances in average educational attainment and in primary and secondary educational quality.

Of course, the individual communities exhibited substantial differences in capabilities to diversify beyond the NASA program and build an economic base for longer-term growth. For example, Huntsville's attempt to broaden its economic base beyond the dominant NASA program was more successful than Brevard County's. Although much of Huntsville's progress stemmed from organized industrial development, the technological characteristics of NASA activities at Marshall Space Flight Center nonetheless afforded Huntsville an important advantage in its diversification efforts. The Marshall Center had primary responsibility for the manufacturing and testing of rocket propulsion units, such as the first and second stages of the Saturn V launch vehicle. In contrast, the John F. Kennedy Space Center at Cape Canaveral acted as NASA's prime launch facility and, as such, required no development or manufacturing activities. The engineering and manufacturing programs at Marshall thus provided a firmer base for attracting industry than did the launch, maintenance, and technical service activities at the Cape.

IV. NASA's Influence on the Growth of High-Technology Industries

A brief discussion of NASA's influence on industry in general is included in Appendix Two. However, large government programs can play a particularly essential role in fostering the growth of high-technology industries.

This type of industrial growth is illustrated by the influence of governmental space and defense programs on the semiconductor and computer industries.[7] The birth and rapid expansion of the U.S. semiconductor and computer industries during the late 1940s and 1950s were greatly aided by government space and defense programs. In achieving supremacy in the computer and semiconductor sectors of the world electronics industry, U.S. firms relied on important economic, technological, and manpower support from federal space and defense programs. Three types of economic impacts can be readily identified:[8] (1) direct and indirect financial support for semiconductor and computer R&D; (2) assured demand during the early years of the industry; and (3) the use of space and defense demand to support new firms and to affect the competitive balance within the industry as it matured.

Direct and indirect financial support for R&D by space and defense programs constituted an important factor in the development of the semiconductor and computer industries. Direct financial support for semiconductor R&D totaled $66 million between 1955 and 1961. These government grants encouraged semiconductor firms to greatly expand production capacity during this critical six-year period. In addition to direct R&D funding, semiconductor firms received indirect federal R&D support by serving as subcontractors for weapons systems prime contractors. The Department of Defense estimated that the R&D subcontracts awarded by such prime contractors more than equalled direct R&D expenditures. By the end of the 1950s, total direct and indirect government-financed R&D represented approximately one-quarter of total semiconductor industry R&D expenditures.

Federal agencies, particularly the military services, provided strong financial support for every major U.S. computer development between 1945 and 1955. The Army funded the development of ENIAC (the first electronic computer), for use in trajectory calculations. During the first ten years of electronic computers, major technical advances were achieved as part of the effort to create large computers which met the specifications set by military and other government agencies. Most of these advances subsequently were incorporated into the medium and small scale computers designed for the commercial market. The large U.S. government outlays for computer development during this period dwarf those of other countries, such as Great Britain, and help explain the early dominance of U.S. firms in the computer industry.

Second, federal space and defense programs influenced the computer and semiconductor industries by generating huge markets for such products. Space and defense demand constituted a major factor in the growth of the U.S. semiconductor industry, as learning economies proved essential. Learning economies resulted in dramatic decreases in semiconductor prices; the average price of an integrated circuit dropped from $50 in 1962 to $0.63 in 1973. During the early years of second and third generation component technology, the space and defense market accounted for a substantial part of the sales volume that made these learning economies possible. Space and defense demand represented at least 35 percent (and as much as 45 percent) of semiconductor sales each year between 1955 and 1961 and over 70 percent of annual sales during the first four years of integrated circuit production.

The market for military data processing systems reached the $200-million level before Remington Rand delivered the first Univac for business data processing in 1954. The space and defense market accounted for over 60 percent of all computer sales during the industry's first decade, and the sales of commercial computers did not overtake space and defense hardware sales until 1962.

Third, as both the computer and semiconductor industries matured, space and defense demand promoted competition among existing firms and aided the entry of new firms. New semiconductor companies could enter the market easily given the receptivity of the military agencies and NASA to the products. Several new companies used space and/or defense contracts to establish an initial market position. The first sales of Texas Instruments' silicon transistor and Transitron's gold-bonded diode were directed toward use in military products.

Control Data Corporation, the third largest computer manufacturer by 1965, depended exclusively on military sales when it first entered the industry in 1957. Space and defense business helped IBM's major competitors—particularly Univac, Control Data, and Burroughs—to improve their market position during the 1960s. By 1970, one-fourth of all Univac computers were located in space or defense installations.

In addition to supplying needed sales revenues for firms during the early stages of growth, space and defense demand accelerated the advance of semiconductor and computer technology. The learning economies that have been so important in the semiconductor industry were not an automatic by-product of production. Such learning economies required deliberate planning. The challenging performance and reliability specifications set by the military agencies and NASA accelerated many of these semiconductor learning economies. In this regard the space program's specifications for the integrated circuitry of the Apollo Guidance Computer provided a major impetus for improvements in the reliability of third generation component technology.

V. The Economic Impact of Specific NASA Programs: Meteorological Satellites

Meteorological satellites represent one of the most important technological advances in the history of weather analysis and prediction.[9] The launching of TIROS I (Television and Infrared Observation Satellite) on April 1, 1960 revolutionized weather observation methods. TIROS I demonstrated the effectiveness of meteorological satellites in overcoming limitations of conventional observation techniques. For example, radar, weather reconnaissance aircraft, weather ships, and weather balloons supplied information on less than one-fifth of the Earth's surface; TIROS I encompassed almost the entire globe.

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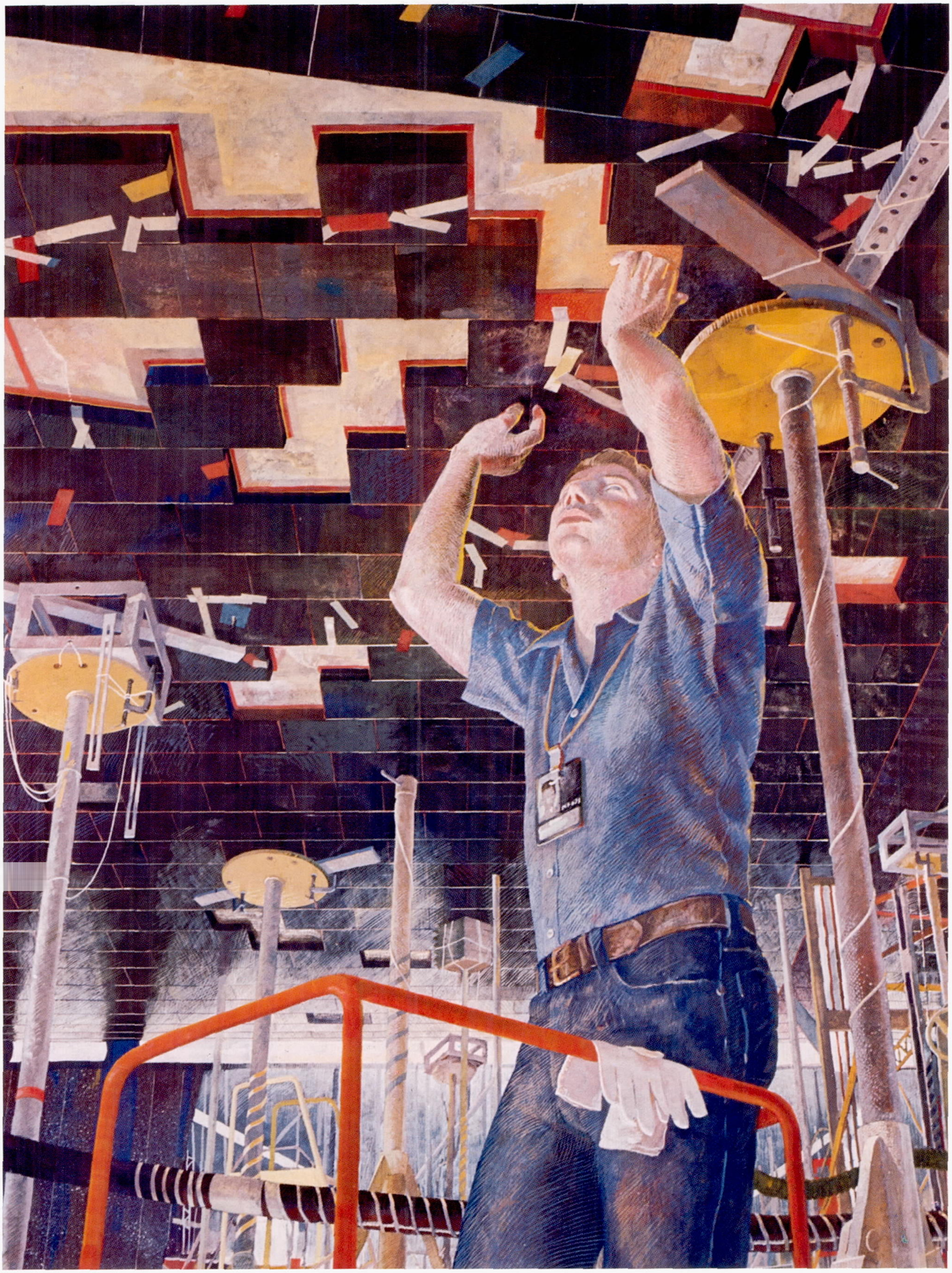

The Labyrinth by Charles Schmidt, gouache, 52½" by 40½".

NASA has served as the R&D organization with the National Meteorological Satellite Program, exercising the responsibility for designing, building, launching, and testing satellites. When a meteorological satellite becomes operational, the U.S. Weather Bureau then assumes responsibility for processing satellite data for operational purposes, disseminating data and forecasts, and conducting research on the climatological uses of satellite data.

The economic benefits of improved weather forecasting can be substantial, because of the significant total value of annual weather-caused losses in the United States. J.C. Thompson's 1972 survey of agricultural, industrial, and other activities suggests that the annual cost of weather-caused losses approximated $12.7 billion. Roughly $5.3 billion of this total could have been avoided with adequate warnings. However, all of such "protectable losses" cannot be avoided, because the costs of protection must be weighed into the calculation as well. Perfect weather forecasts only can salvage about 15 percent of protectable losses, a relatively modest proportion of total protectable losses, but a relatively large absolute savings—$739 million according to Thompson's estimate.[10]

Meteorological satellites have greatly enhanced the accuracy of storm warnings and forecasts; the availability of satellite data produced economic savings over the 1966-73 period of approximately $20 million. However, it appears unlikely that satellite data have as yet improved the accuracy of daily weather forecasts. In fact, the true potential of satellites in weather forecasting will not be realized until satellite data are integrated into numerical weather prediction models, which may occur during the 1980s.

What type of economic impacts can be expected when an operational weather satellite system is implemented and linked to numerical prediction systems? Despite substantial progress in numerical weather prediction, improvements in the accuracy of daily weather forecasts have ranged between 5 and 10 percent. Furthermore, Thompson contends that only 56 percent of estimated economic gains could be achieved using more accurate forecasts. Therefore, if the use of satellite data increased current levels of forecast accuracy by another 5 to 10 percent, annual economic savings would range between $20-40 million ($739 x .56 x .05 or $739 x .56 x .10). It is important to recognize that these projected savings represent a small fraction of the potential economic benefits. The contributions of weather satellites and numerical weather prediction to weather forecasting will not be fully exploited until two major barriers are overcome.

First, substantial improvements in the dissemination of weather information are required. The most pressing demand in this respect is to provide the user with specific types of necessary weather information. As an illustration, most economic models estimated potential savings from better forecasts by focusing on how users could make optimum use of weather information in decisionmaking. Such models presume that weather predictions include information on uncertainty. However, the National Weather Service began to meet this requirement only recently by disseminating probability forecasts.

Second, decisionmaking by farmers, businessmen, builders, and other users of weather information is far from optimal. The inadequacy of present decision strategies is demonstrated by Thompson's contention that 44 percent of estimated potential economic gains could be achieved through better use of *current* forecasts. The economic benefits of more accurate weather forecasts are unlikely to materialize unless users employ decision strategies that capitalize on the new information.

VI. Studying Economic Impacts of the Shuttle Program

The analysis in this paper documents that the space program has generated several distinct, diverse, and far-ranging economic impacts, including: economic expansion in cities and surrounding regions, acceleration of technological advances, and growth of new industries and scientific fields. The past space programs suggest the types of economic results that are likely to flow from the Shuttle program. A logical starting point for the examination of potential Shuttle program impacts would utilize the frameworks of earlier studies. Specifically, the following questions concerning program scale, geographical location, linkages with industry, and linkages with science and engineering should be considered:

A. Scale

(1) How large are past, current, and future Shuttle program budgets?

(2) What are the direct and indirect employment levels of the Shuttle program?

(3) What is the research and development component of Shuttle program expenditures?

(4) How do the level and pattern of Shuttle program expenditures and employment levels compare with those of the Apollo program?

B. Geographical Location

(1) Which NASA facilities perform the bulk of Shuttle program work?

(2) Is the Shuttle program concentrated in one or two locations?

(3) Has there been a sharp increase in program activity and employment at particular NASA locations?

(4) Are the most active Shuttle program facilities located in major cities (e.g., Houston) or in smaller, less developed areas (e.g., Brevard County, Florida)?

(5) What are the previous patterns of economic development in the principal Shuttle locations?

(6) How does the network of Shuttle program locations compare with the pattern of manned space program facilities?

C. Linkages with Industry

(1) Which industries (by SIC classification) supply the largest numbers of goods and services to the Shuttle program?

(2) How does this pattern of industrial expenditures for the Shuttle program compare with the pattern for the manned space program?

(3) Are distinct new technologies required by the Shuttle program? What are the potential industrial applications of these new technologies?

(4) Are there new industries and/or new firms that have been launched as the result of Shuttle program support?

(5) How have Shuttle program expenditures affected competition among firms in particular industries?

D. Linkages with Science and Engineering

(1) What is the pattern of basic and applied research funding in the Shuttle program?

(2) What scientific and engineering disciplines have received the major share of these basic and applied research funds?

(3) How does Shuttle program funding within these disciplines compare with total federal support for each discipline?

(4) Has the Shuttle program made it necessary to attract new manpower to particular disciplines? Which disciplines have had the largest manpower increases?

(5) Have new fellowship programs and other forms of graduate student support been established to meet the manpower needs of the Shuttle program?

This checklist of questions will provide the student with detailed information on key dimensions of the Shuttle program. In addition, the student should draw on generalizations provided by earlier studies: for example, previous reports clarify that economic impacts of the space program have depended on the relative importance of the new resources made available by NASA in comparison to those from existing resources. Hence, NASA produced a much greater impact on Huntsville, Alabama and on the communities in Brevard County, Florida than on Houston, Texas.

Despite the many positive economic impacts of the U.S. space program, NASA's role has not been free from criticism. Some analysts have complained that the U.S. space and defense programs created imbalances in the nation's supply of scientific and technological manpower. In some areas of engineering and science, these federal programs helped to produce a supply of engineers and scientists that exceeded demand in subsequent years. As NASA and the Department of Defense provided substantial funding and devoted specific efforts to attract and educate more scientists and engineers, these agencies assumed difficult responsibilities. The instability of government funding and sudden program changes have adversely affected the supply and morale of scientists and engineers.

For these reasons, it is inappropriate to dwell only on the positive economic effects of the Shuttle program. The careful researcher also must be sensitive to potential negative economic consequences.

Appendix Two also includes a case study of NASA's economic impact on the science of astronomy.

Footnotes

1. L.G. Reynolds. *Economics.* (Revised edition.) Homewood, Illinois: Irwin, 1966, p. 534.

2. E. Mansfield. *Technological Change.* New York: W.W. Norton, 1971, pp. 1-7.

3. Midwest Research Institute. *Economic Impact of Stimulated Technological Activity.* Kansas City, Missouri: Midwest Research Institute, November 1971.

4. Chase Econometric Associates, Inc. "The Economic Impact of NASA R&D Spending: Preliminary Executive Summary." NASA-2741, April 1975. Also: "Relative Impact of NASA Expenditure on the Economy." Unpublished NASA Staff Report, March 18, 1975.

5. Rockwell International, Space Division. "Impact of the Space Shuttle Program on the California Economy." FD-74-SH-0334, December 1974.

6. The data contained in this section are based on: Ronald Konkel and Mary Holman. *Economic Impact of the Manned Space Flight Program.* National Aeronautics and Space Administration, January 1967; Ronald Konkel. "Space Employment and Economic Growth in Houston and New Orleans, 1961-1966." Tulane University MBA Thesis, June 1968; *Stanford Research Institute. Some Major Impacts of the National Space Program: Economic Impacts.* N68-3438, June 1968; and U.S. Congress, House of Representatives, 88th Congress (2nd Session). *Impact of Federal Research and Development Programs.* House Report No. 1938, Study Number VI, 1964.

7. During the early stages of this study, it became clear that NASA's impact on computers and semiconductors was intertwined with the influence of the U.S. defense program. The Department of Defense certainly accounted for the largest share of federal spending on computers and semiconductors. Consequently, the combined influence of the space and defense programs was examined.

8. These economic impacts, along with the technological and manpower impacts of the space and defense programs, are discussed more fully in: J. Schnee. "Government Programs and the Growth of High-Technology Industries." *Research Policy.* Vol. 7, No. 1, January 1978, pp. 2-24.

9. The material in this section is based on the more comprehensive discussion in: J. Schnee. "Predicting the Unpredictable: The Impact of Meteorological Satellites on Weather Forecasting." *Technological Forecasting and Social Change.* Vol. 10, May 1977, pp. 299-307. Also: E. Ginzberg, J. Kuhn, J. Schnee, and B. Yavits. *Economic Impact of Large Public Programs: The NASA Experience.* Salt Lake City: Olympus Publishing, 1976, pp. 115-41.

10. J.C. Thompson. "The Potential Economic Benefits of Improvements in Weather Forecasting." San Jose, California: Department of Meteorology, California State University, September 1972, pp. 7-12.

History

The Relation of History to Space Technology

Walter A. McDougall
Woodrow Wilson Center for Scholars
Smithsonian Institution

The Second Giant Step by Lamar Dodd, oil, 38″ by 56″.

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I. Introduction: Nature and Relevance of History

A. Varieties of Space History

There are as many potential varieties of space history as there are varieties of history. At the risk of offending individual sensibilities, they can be broken down. The first category of historians (and the most familiar to the general public) includes the chroniclers of the first two decades of exploration of space. Such historians are drawn primarily from the ranks of journalism and concentrate largely on the manned missions of the U.S. and the U.S.S.R., especially during the putative space race of the 1960s. Such historians write the books that are most exciting to the general public but least interesting to professional historians. Nonetheless, whatever the academic value of their labors, the journalistic historians of the space age go far to create the public enthusiasm that is apparently vital in a democracy for a healthy civilian space program.

A second variety of space historians encompasses the technical or "nuts-and-bolts" historians of technology. These writers have described in detail the evolution of rocketry, telemetry, guidance, and all the other


Lamar Dodd '81

engineering techniques that comprise astronautics. Such historians frequently are former space program participants and/or are sponsored by NASA's own history program. Devotees of technical history often dismiss the more popular histories of journalists or political historians because of the generalists' lack of technical expertise. To a degree, such a view is valid—problems of causation in the history of technology often are warped by writers unfamiliar with the technical constraints on policy.

Space age history analyzed as history of science forms a third category. Like all modern technology, spacecraft evolved initially because of advances in pure science—whether the mathematics of orbital mechanics, the chemistry of high-energy cryogenic fuels, or the physics of solid state electronics. Once satellite launching became routine, space science (the continuing pursuit of all our familiar sciences from the laboratory of space) stimulated revolutionary advances in numerous fields. For example, the astronomical and astrophysical discoveries alone are epochal. To the historian of science, such developments constitute the stuff of space age history, and the engineering feats of the rocketeers pale by comparison.

Finally, there are the historians who focus on the impact of space technology and exploration on political, social, and economic issues. To be sure, the interests even within this group are numerous and include the impacts of space activity on: international strategy and law, government science policy and organization, domestic economies and social change, even cultural and religious values. But these social-scientist space historians represent only one group among many, and works from other historians are indispensable for defining the precise nature of the phenomena that social scientists presume to trace through the "cloud chamber" of society.

This paper focuses on issues of interest to the latter group of historians, whose approach is most relevant to the users of this book.

B. Definition of History

History is a multifarious discipline and hence can be defined only in the broadest and least distinctive terms. History encompasses quite literally everything that human beings have ever done, thought, or experienced. As an academic discipline, history represents the art (not science) of establishing and explaining past events; its scope is therefore potentially limitless. The problem in history is not divining which issues historical research can help us understand or what questions it can help us answer; rather, the task is pruning out all the data and questions of less relevance to whatever problem is at hand. Therefore, history can be described as a discipline of *selection,* and ultimately the value of a given historical work is defined by what material is *left out.*

C. The Historical Method and Space Technology Research

The unique comprehensiveness of history (vis-a-vis other disciplines) in regard to Shuttle technologies constitutes a great handicap and a great advantage. History's fluid and empirical nature acts as the handicap of the historical method in a project analyzing the past and future social impact of technology. The historian seeks the particular, not the general, and tries to identify and explain those qualities that make a given phenomenon *different* from all others. On the other hand, the social scientist seeks to identify and explain those qualities that make a given phenomenon *like* others. Thus, the historian views with suspicion precisely the sorts of models or general laws that represent the very building blocks of the sociologist, economist, or political scientist. To the historian, it is never self-evident how a given datum ought to be understood in a historical context, because both the event and the historian are unique. Consequently, a given fact never will carry the same weight for two different historians nor be subject to the same interpretation. Without probing more deeply into the epistemological vagaries of historical work, analysts simply should keep in mind that history represents a product of the imagination, even of instinct. Of course, historians try to gather data on the past in a more or less scientific fashion, but arranging and making sense of the raw material is not an act of calculus dictated by some general theory or model, but rather an act of creation molded by the historian's insight into the unique circumstances of the historical moment.

The above qualities create difficulties when historians work with other social scientists or analyze events as current as the space program.

Nevertheless, the nature of history also produces an advantage. History is an integrative discipline. By training and instinct, the historian tends to: integrate knowledge about the various classes of human endeavors (political, economic, social, intellectual) at a given historical time and place; break down historical phenomena into constituent parts, according to those same classes; and then relate the parts to the whole. As a result, the alert historian naturally would: become familiar with the chronological history of space technology and policy; think at once of the political, economic, and other factors relevant to the origin and growth of the technology; and finally seek to establish empirically the causal links among such factors. Therefore, technology, in the context of this paper, would not be a "given" to be applied to "political life" or "the economy," but rather would become a mediator within the complex organism of the nation.

By way of introduction, a final issue must be addressed: the troublesome question of history's role in aiding analysis of the *future* social impact of relevant Shuttle-derived technologies. After all, history focuses on the past. Most historians are skeptical of historical study even of events that occurred during the last thirty years, believing it impossible to obtain perspective and adequate sources on such recent happenings. Thus, the entire space age lies outside the "proper" realm of historical study, and historians take professional risks when they concentrate on the space age. But the Shuttle and its social impact lie in the *future.* Other social sciences may claim some

predictive capabilities (though even these are suspect), but history certainly cannot stake out the future as its domain. (Or can it? One can argue that, to the extent we can creatively study the future at all, the appropriate approach is not the social scientists' crude extrapolations and models, but precisely the historian's imagination and sense for the *un*expected in human affairs.) How can the historian help society to think about space technology? And how does the advent of the Shuttle and its ancillary technologies help society in turn to think about history? The answers require imaginative, in addition to mechanical, analogical thinking.

D. Summary of Two Approaches

There are thus two historical approaches to the "Shuttle and society" question. The first approach encourages and organizes materials for the study of space technology in the *past* (i.e., to and through Sputnik and up to the present). The second approach begins with the Shuttle and derived technologies and seeks analogies in historical time, literally firing up the imagination about the types of changes made possible by space technology in the political, economic, scientific, social, and philosophical/ethical life of humanity over the next half century.

II. The History of the Space Age

A. Justification

The writing and teaching of the history of the space age (conventionally dated from 1957) must assume increasing importance as the impact and promise of space technologies grow and as young people become increasingly removed from our space heritage. Consider that current undergraduates were born *after* JFK urged us to go to the Moon (May 25, 1961) and barely recall Apollo 11.

The history of the space age possesses great value for contemporary college students, because it requires a basic awareness of the fundamental origins of our own technological and international environment. To understand the evolution of space policy and technology, the student must become familiar with the roots and course of the Cold War, the origins and nature of nuclear weapons and strategic missiles, the logic of the arms race and the interplay of international rivalry and technological progress, the policymaking process in the U.S. and the U.S.S.R., the values and style of government that make the U.S. distinctive, and the exceedingly great power of the modern state to change society—for better or worse—by force-feeding science and technology. Traditional history courses (regardless of sub-discipline) do not necessarily inform the contemporary college student about how the world got to be as it is. But seminars or lecture series focusing on the dawn and development of the space age educate students in precisely the areas of knowledge that equip them to think effectively and analytically about the contemporary world.

B. Themes and Issues

The history of American and world space policies embraces a number of themes that are critically important in this age of perpetual technological revolution, including:

(1) *Cooperation vs. competition among nations in space.* Space seemed a natural arena for international cooperation in the late 1950s and early 1960s, yet the space race was born of Cold War military rivalry. Throughout the space age, the dream of a united humanity in space has confronted the reality of competition for security and prosperity—and the blunt facts that competition breeds funding and that technology develops most efficiently when in the hands of coherent national teams.

(2) *Regulations vs. laissez-faire.* Soon after the launch of Sputnik, the United Nations formed a standing committee to regulate space activities and/or draw up principles of behavior. Many observers hoped for an international space agency and a detailed Magna Charta for space law, but the politics of the U.N. and of great-power technology investment weigh against such close regulation. Space law negotiations formulated some laudable principles and some pragmatic agreements on lesser issues, but the great powers understandably have opposed U.N. control of their technologies.

(3) *Military vs. civilian control.* During the past twenty-five years, space technology has been applied to military and civilian uses. An important issue is which government agencies should control development and/or use of the technology. The Soviets never have made false distinctions, but the more sensitive Americans have, with some complicated results. To understand the likely impact of the Shuttle, one must thoroughly study the history of bureaucratic and interservice rivalry for control of missile and space technologies.

(4) *Science vs. engineering.* The world's space programs began as scientific and military enterprises, but soon the engineers predominated over the pure scientists, and space science has been a stepchild ever since. The contrasting attitudes and mindsets of scientists and engineers and their impact on policy constitute an important element of space history.

(5) *Prestige vs. applications.* What are the motives for large investments in space technology, and do they conflict with each other? What does the history of various space policies suggest about the societies and political cultures that produced them? Whether applications satellites, military systems, or scientific ventures, practical space programs often are less able to command funds than technological projects designed to serve prestige or political purposes, be it Apollo or the Chinese "East is Red" satellite.

(6) *Technological determination vs. political choice.* How can societies control the evolution of space technology in the last analysis? Is there a deterministic element in space exploration, and if so, what is its origin—international competition, the innate human desire to explore, the patterns of growth produced by

technology, creation of powerful "military-industrial complexes," or some other factor?

These issues are by no means reducible into "good" and "bad" sides, or even into "realistic" and "idealistic" approaches to space policy and potential futures. Rather, our traditional preferential yardsticks are unreliable. "Cooperation" stifles rapid growth; "regulation" kills investment; "civilian control" is illusory when identical systems can be put to military or civilian uses; and "militarization" of space is not a priori a bad thing in any case. In fact, for all these issues in space history—issues that will challenge the Shuttle and that must be understood in the historical context—there are sound cultural values supporting both sides of the debate. Thus, the study of the history and future of domestic and international space policy constitutes a useful tool for analyzing some of the most crucial dilemmas confronting late twentieth century society.

(C) Selected Research Topics

Specific historical problems suitable for classroom study and research include: (1) the origins of Sputnik and Russian astronautics; (2) the impact of Sputnik on U.S. science policy and society in general; (3) the roots and organization of the U.S. space program; (4) the decision to go to the Moon; (5) the struggle by the U.S. Air Force in the 1950s to control the space program; (6) the impact of Apollo on the space program and society as a whole; (7) successes and limitations of international law and cooperation in space; (8) the origins of the Space Shuttle; (9) the administrative history of NASA and its relations with other agencies, the aerospace industry, and universities; and (10) the history and goals of the Soviet, French, European, Japanese, Chinese, and/or Indian space programs.

(D) Space Age History and the Future

Finally, the whole point of the historical exercise is to comprehend the current political environment in which the Shuttle operates. What is the organizational, international, and programmatic context of the Shuttle, Spacelab, and other related systems? After all, this age still represents the infancy of spaceflight. Barring war or a scientific Dark Age, world operations in space will increase exponentially over the next fifty years. For now, policymakers still are functioning in the formative years, when the patterns and rules of the space game are being established. If the Shuttle is to elevate the space age to maturity—and if "the child is the father of the man"—then policymakers must understand the history of the early decades in space in order to be sensitive to its offspring.

III. The Future as History: Analogical Approach

A. The Use and Abuse of Analogy

What does the space age mean to humanity? How can the world possibly grasp the impact of the revolution precipitated by space technology and resultant pioneering of the limitless medium of space? In 1962, Bruce Mazlish addressed this question, and almost two decades later, it is difficult to improve upon the logic and imagination of *The Railroad and the Space Program: An Exploration in Historical Analogy.* This book must constitute the starting point for discussions of the use of analogy in judging the current and future impacts of space technology.

Historical analogies are irresistibly enticing. The most natural mental processes incline human beings toward conjuring up like things and situations from experience as a means of processing current data acquired through our senses. For space law, analysts find it impossible not to think of the Law of the Sea or the Antarctic Treaty. For space exploration in general, one thinks of the Spanish voyages of discovery. For control of new and forbidding technologies, how can one resist the analogy of the atomic bomb and nuclear power? Yet, all analogies are vain except for purposes of narrow illustration—or to explain how past statesmen themselves may have been influenced by the same analogies. Mazlish correctly identified the space phenomenon as more than a "new frontier," a "new technological breakthrough," or a "new battlefield among nations." He viewed space exploration as a technological complex that came to represent a social invention, as society was forced to restructure itself in many ways to accommodate the new technology. And in searching for a historical analog to the space social invention, Mazlish concluded that the coming of the railroad was most fitting. No other previous invention so changed the very proportions of space and time and power as the railroad. This is a subtle and complex analogy, which Mazlish and the other contributors to his volume examined in depth. Unfortunately, historical analogy is abused far more than fruitfully used. Facile comparisons to Columbus do a disservice to history and to the effort to understand the space phenomenon. But flexible and nuanced consideration of past explorations and inventions can provide insights into possible future paths.

B. Analogy and Imagination

How can an instructor employ analogies like the railroad and its impact on American history to understand the Shuttle-derived technologies and their impact? The answer includes the exercise of historical judgment to temper and stimulate the imagination about the possible pace of change and existing barriers to change, as well as to anticipate novelty, rather than assume continuities. Some examples:

(1) *Item:* The Space Shuttle.
Potentials: Rapid increases may occur in the volume of space activity in fields where practical payoff is assured. Great decreases in cost-per-pound of launches may be possible, and tolerance for discretionary and risky enterprises may increase as well. The Shuttle is a likely stimulus to terrestrial technology and industry.
Analogs: The advent of seaworthy "workhorse" merchant vessels, such as the Dutch *fluit* of the seventeenth century, is analogous to the Shuttle. Trade in Asian spices or South American metals

is not similar to Shuttle space transport, but the coming of economical *bulk* shipping does represent a useful analog. Space likely will provide little in the way of precious cargo; the Shuttle provides the boon of ready access to a new environment, which in turn will permit greater economic division of labor and differentiation. This compares well to the effect of bulk transport in cereals, in the Baltic Sea in early modern times, and in trans-Atlantic shipping of American grains in the 1870s. Both times the new transportation capability altered world economic patterns (in the early case, with great stimulus for West European economic modernization).

(2) *Item:* Spacelab and Space Telescope.
Potentials: These scientific projects may produce untold revelations about the universe, and data may multiply literally a thousand times at a blow. Spacelab should provide a cheap, flexible, reusable facility for experiments impossible on Earth, generating a substantial increase in the capability and efficiency of space-based R&D in materials processing and basic science.
Analogs: The Galilean telescope also enlarged the universe many times and changed forever mankind's view of the world and the cosmos, producing profound scientific, philosophical, and religious changes. Other such "eye openers" would include the Pacific voyages of Cook and Darwin and the advent of spectroscopy.

(3) *Item:* Space applications satellites.
Potentials: A communications revolution promises a "satcom center" (with possible computer links) in every U.S. home, thanks to communication satellites with functionally limitless capacity. Hundreds of cable television stations could supply instant gratification of every visual/audio desire (but with what moral and cultural effects?). For the Third World, satellites can offer direct broadcast television for education and propaganda purposes. Landsat will produce economic benefit from new applications of remotely sensed geophysical data.
Analogs: The common comparison for the communication satellite revolution is the advent of the Gutenberg printing press in the fifteenth century; the cultural revolution that followed needs no elaboration. But another analog usually overlooked is the invention of the linotype machine in the late nineteenth century, which brought the penny press to the masses. Combined with universal education, mass journalism changed the politics and culture of Europe and America as few other innovations.

C. Summary

In all these analogies, one still must be very careful to understand the differences between the historical environment in which the changes occurred and the historical environment in which the Shuttle operates. The most important difference applicable in every case is, perhaps, the all-powerful role of the state, "Leviathan," in the funding, organization, and execution of space activities. The likely effects of space technology would seem *more* predictable as a result of state control; in fact, a monopolistic state, for various reasons, also may stifle the revolutionary potential of space technology. Would the printing press have spread freely throughout Europe if a single state had been in monopolistic possession of the technology? One has cause to wonder—great cause.

Appendix Two materials provide insights from two experienced instructors who have integrated space into history courses.

Rollout, Columbia by Martin Hoffman, oil, 50″ by 70″.

International Law & Relations

International System and Space Law: An Introduction

Harold M. White, Jr.
Western State College of Law

Spacelab I by Charles Schmidt, oil, 52″ by 72″.

The space age presents new challenges to self-government, freedom, and the sovereignty of the individual. Travel, interaction, and information exchange occur at an unprecedented frequency and level of complexity. Social science faces the fact that institutions are more bureaucratic in character, pervasive in impact, and global in nature. The international legal system denies legal standing to individuals and non-government organizations, yet attempts to enhance their status through a nation-state centric system of international law that has not extended sovereignty below the level of national governments. The entrance into space imparts new perspectives and raises new questions, much like the discovery of the New World.

To effectively analyze the international impact of space programs, one first must ask precisely what *is* the international system? What organizational structures are now of paramount importance? Are there any analogies between the ideology manifested in the American revolution and that characteristic of today's international system? What are the prospects for the future development of a "supranational system?"

By current definition, the international system includes virtually every body that is organizational in character and influences—but operates outside of—a local or

regional community. Even some regional activities have international overtones, and this is equally true of both public and private organizations, from governments to corporations and associations. For example, a growing number of domestic businesses employ communications satellites, and more and more businesses conduct day-to-day operations which are dependent on communications. Thus, there is a growing interdependency between organizational and legal life.

Law represents a system of social interaction, either agreed upon or decreed. In its various incarnations, law applies to nations, states, organizations, and individuals. In an ideal form, law constitutes the creative, just, and efficient institutionalization of ideas.

The four major categories of law are: (1) domestic public, (2) domestic private, (3) international public, and (4) international private. Domestic public law includes personal contracts, organizational contracts, and corporate structures. International public law encompasses the United Nations system and bilateral or multilateral intergovernmental treaties or organizations (for example, the European Space Agency, or the Helsinki Accords on European Peace and Security[1]). This international public system of law generates the most controversy. International private law focuses on private organizational transactions and non-governmental contracts and associations, including everything from Aramco's relationship with its subsidiaries to the non-profit International Astronautical Federation and its Institute of Space Law.

Because of the high degree of interdependency in modern organizational life, it is sometimes difficult to delineate public from private, domestic from international. For this reason, a perception of the international system that is based merely on the fractiousness of the United Nations Security Council or on the notable ineffectiveness of the World Court can be inaccurate and not even genuinely reflect the activities of the United Nations itself.

As is readily apparent from Figure 1, the United Nations manages a multiplicity of functions. Some U.N. bodies are familiar to Americans, such as the UNICEF Committee, the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the International Civil Aviation Organization (ICAO). This paper focuses primarily on those segments of the international system that relate to outer space activity and space development. This approach not only will illustrate the various types of organizations within the international system, but also will indicate those areas of international law that still draw most powerfully upon the concepts of freedom, individual sovereignty, and institutional interdependency that inhere in the American Constitution and are central to humanity's movement into space. Therefore, this paper will progress from the systems that currently exist to the underlying ideology (and, thus, the future).

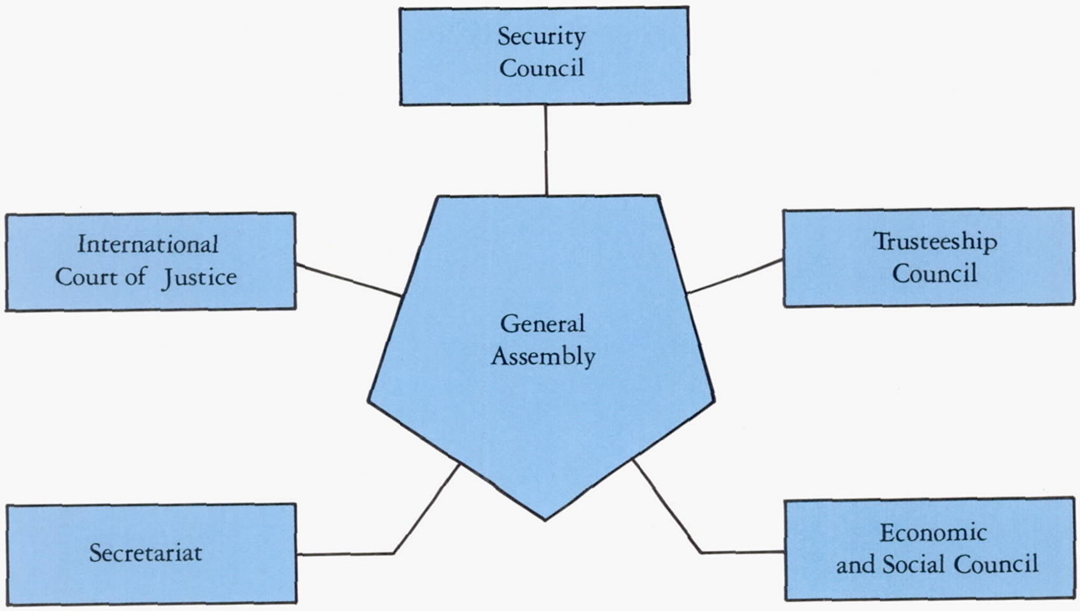
The purposes and principal organs of the United Nations are described in Appendix Two.

Beyond the organs, committees, and intergovernmental specialized agencies of the U.N. lie the various non-governmental organizations—from the multinational corporations, which live among both the competing and overlapping influences of domestic and international public and private law, to the great international unions and federations of professional associations, which operate increasingly at the public international level. Indeed, almost any non-profit, non-governmental organization may affiliate with the U.N. system in one of several categories. Organizations old enough and fortunate enough to be affiliated with the Economic and Social Council as consultant observers (in contrast to affiliates of the Secretariat's Department of Public Information) are even allowed to hold their own advisory voting assemblies at specialized U.N. conferences, such as the Second United Nations Conference on the Peaceful Uses of Outer Space held in Vienna in August 1982. Of course, the assembly of the representatives of member governments is the "official" assembly at such events. These conferences are especially noteworthy for information exchange and consciousness raising, if not for successes in political accommodation.

The International Astronautical Federation (IAF) exemplifies the non-government organization affiliated with a specialized agency, in this case the United Nations Educational, Scientific, and Cultural Organization (UNESCO); see Figure 1. The IAF began as an international congress of professional astronautic societies, such as the German Society of Space Research and the American Rocket Society (now the American Institute of Aeronautics and Astronautics). IAF vigorously pursued both expert efficiency and affiliation with the United Nations. The IAF has sponsored annual International Astronautical Congresses since 1950. IAF also formed the influential International Institute of Space Law and has conducted annual Colloquia on the Law of Outer Space since 1958. In order to affiliate with the non-government International Council of Scientific Unions (ICSU), IAF established a scientific arm called the International Academy of Astronautics. Affiliation with ICSU and its prestigious International Committee on Space Research (COSPAR) not only speeded affiliation with UNESCO, but also strengthened IAF's role among the non-governmental organizations as the primary body responsible for the interdisciplinary study of astronautics.

The International Telecommunication Union (ITU)—see Figure 1—represents a good example of an intergovernmental agency in the space development field. Non-governmental organizations such as IAF have worked closely with and influenced this important intergovernmental organization. Indeed, the ITU constitutes a unique example of the real practical and functional authority that can be wielded in the international system, quite apart from the General Assembly or the Security Council. ITU's primary task is the allocation of radio frequencies. This responsibility assumes enormous importance when one considers the substantial number of communications satellites from many different countries that seek to use different segments of the electromagnetic spectrum for different purposes. The World Administrative Radio Conference (WARC) is the ITU

Figure 1
The United Nations and Related Agencies



*Related Agencies**

Security Council
Military Staff Committee
Disarmament Commission
United Nations Operations in the Middle East
International Atomic Energy Agency

General Assembly
United Nations Scientific Advisory Committee
Scientific Committee on Effects of Atomic Radiation
Committee on the Peaceful Uses of Outer Space
Committee on Information from Non-Self-Governing Territories
International Law Commission
Advisory Committee on Administrative and Budgetary Questions
Committee on Contributions

Other Subsidiary Bodies of General Assembly:
Disarmament Commission
United Nations Administrative Tribunal
International Atomic Energy Agency
United Nations Emergency Force
United Nations Relief and Work Agency for Palestine Refugees
United Nations Special Fund
United Nations Childrens Fund (UNICEF)
Office of United Nations High Commissioner for Refugees

Secretariat
Administrative Committee on Coordination
Technical Assistance Board

Economic and Social Council
International Atomic Energy Agency
United Nations Special Fund
United Nations Childrens Fund (UNICEF)
Office of United Nations High Commissioner for Refugees
Regional Economic Commissions
Functional Commissions
Administrative Committee on Coordination
Technical Assistance Board

Specialized Agencies:
International Labor Organization
Food and Agriculture Organization of the United Nations
United Nations Educational, Scientific, and Cultural Organization
World Health Organization
International Development Association
International Bank for Reconstruction and Development
International Finance Corporation
International Monetary Fund
International Civil Aviation Organization
Universal Postal Union
International Telecommunication Union
World Meteorological Organization
Inter-Government Maritime Consultative Organization
International Trade Organization

**Some related agencies are listed under more than one U.N. body; in these cases the related agencies report to and/or serve both U.N. bodies.*

arm that addresses space communications—which, in today's diversified market, affects nearly all forms of communication, both domestic and international. WARC is divided into three regions; North and South America are in region two.[2] Region two is now the world's only remaining area recognizing an "open skies" policy. The other regional WARCs have begun the allocation of geosynchronous orbit slots, because of the limited number of usable sites available in the geosynchronous orbit (roughly 35,881 kilometers, or 22,300 miles, above mean sea level).

Few recognize the importance and impact of international organizations like the ITU, which often are obscured by the general perception that the international system is ineffective. Gone are the days when domestic communications policy could be developed without regard to international implications. The types of private investment characterizing the American communications market depend in large part on secure and recognized frequencies. The ITU alone includes seventy-five different committees, study groups, and interim working parties, each with the potential to exert a significant impact on international telecommunications issues. Many observers are surprised to learn that the ITU's predecessor, the International Telegraph Union, dates from 1865; it was transformed into the ITU in 1947 and became a specialized agency of the U.N. in 1949.[3]

Indeed, several of the current specialized agencies can claim venerable origins. For example, the World Meteorological Organization (WMO) has roots that stretch back to 1853, when ship owners throughout the world exchanged meteorological observations on the oceans.[4] The WMO acts as a clearinghouse for data cooperatively shared among the weather services of the member nations. Increasingly complex and valuable exchanges of information now occur, drawing data not only from satellites and ground and oceanic stations, but also from in-progress comparative meteorological studies of other planets in our solar system.

Figure 2 includes only a *few* of the international bodies concerned with outer space. Even enormously important bodies like ITU, WMO, and UNESCO seem buried in acronyms under the Office of Inter-Agency Affairs; an important organization like the IAF might appear (to the uninitiated observer) to have little direct influence. Moreover, a multiplicity of international public and private organizations have a direct bearing on space-related activities. Figure 2 doesn't even include private and/or commercial organizations, such as International Telecommunications Satellite Organization (Intelsat)[5] or other multinational corporations. Nor does Figure 2 include other important intergovernmental bodies, such as the European Space Agency, which is building Spacelab.[6] Indeed, NASA itself, like many other domestic organizations, includes a Department of International Relations, which negotiates launch services for international payloads and advises the government on questions of international law relevant to space activities.

Explanation of Acronyms Used in Figure 2

Specialized Agencies

ILO	International Labor Organization
FAO	Food and Agriculture Organization of the United Nations
UNESCO	United Nations Educational, Scientific, and Cultural Organization
WHO	World Health Organization
ICAO	International Civil Aviation Organization
ITU	International Telecommunication Union
WMO	World Meteorological Organization
IMCO	Inter-Governmental Maritime Consultative Organization
IAEA	International Atomic Energy Agency

Other Inter-Governmental Agencies

ESRO	European Space Research Organization
INTELSAT	International Telecommunications Satellite Organization
INTERSPUTNIK	International System and Organization of Space Communications

Non-Governmental Organizations

ICSU	International Council of Scientific Unions
COSPAR	Committee on Space Research of the ICSU
IAF	International Astronautical Federation
ABU	Asian Broadcasting Union
EBU	European Broadcasting Union

Others

Office of Inter-Agency Affairs

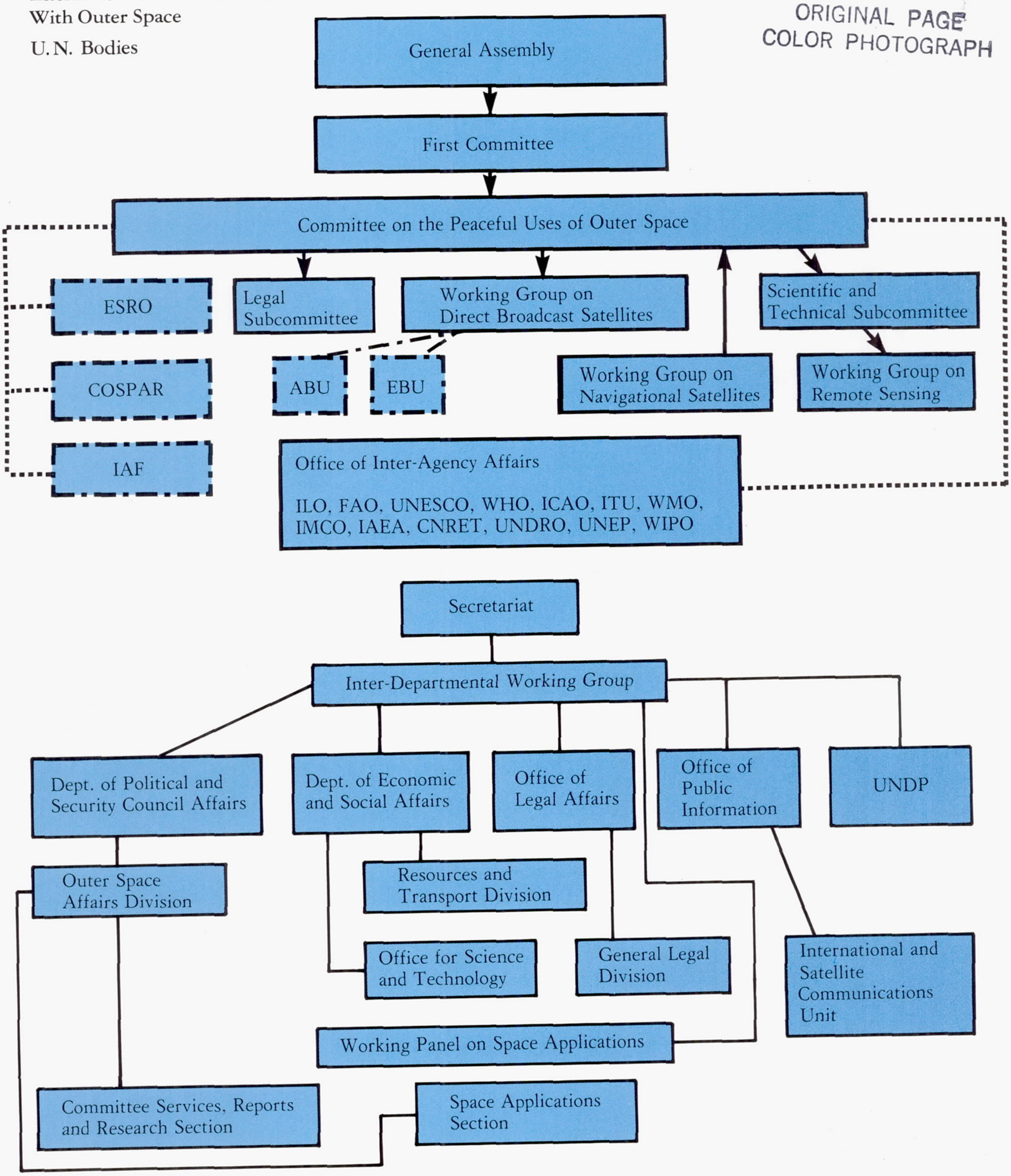
WIPO	World Intellectual Property Organization
CNRET	U.N. Centre for Natural Resources, Energy and Transport
UNDRO	U.N. Disaster Relief Organization
UNEP	U.N. Environment Programme

Miscellaneous

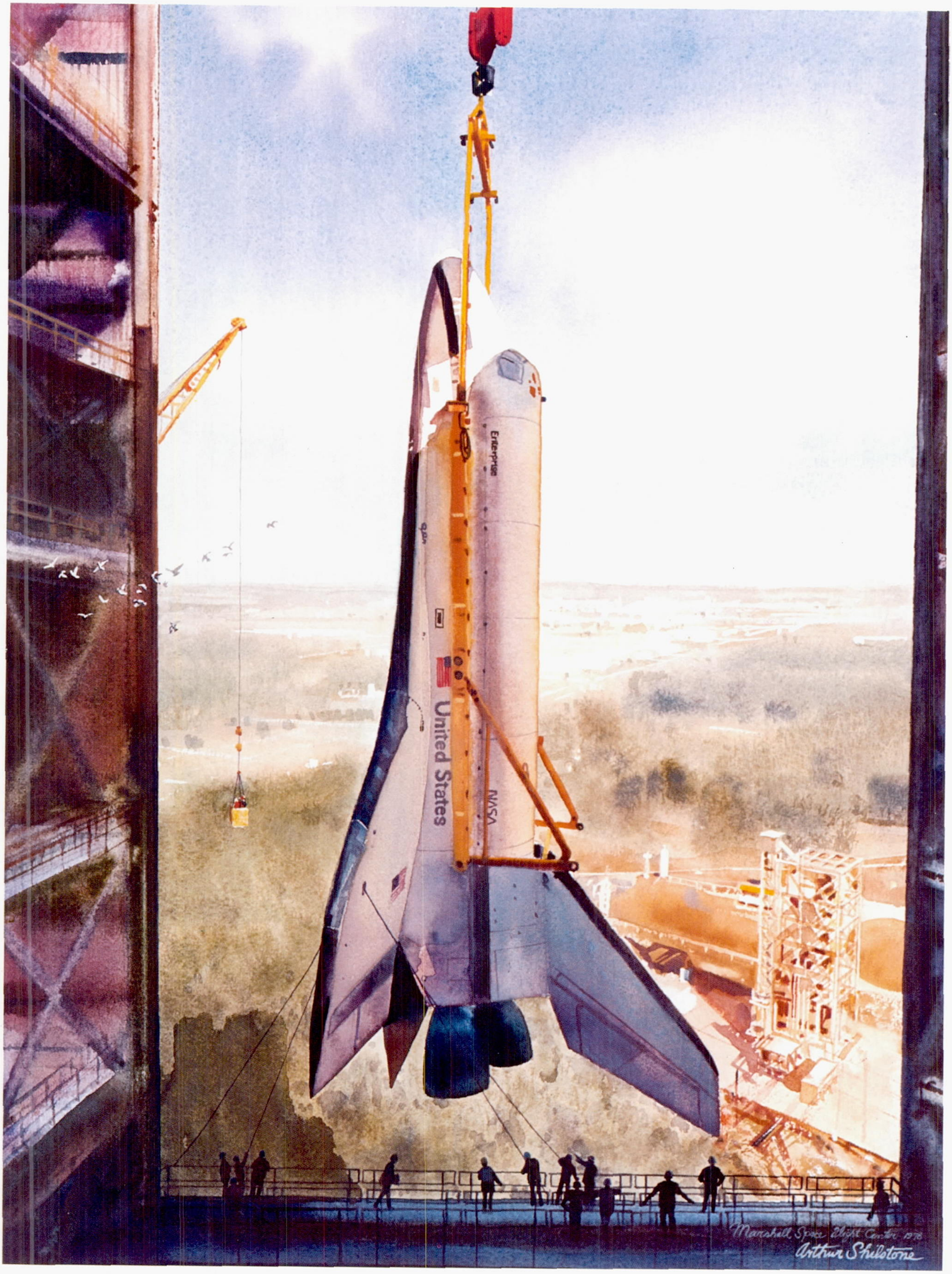
UNITAR	U.N. Institute for Training and Research
UNDP	United Nations Development Programme

Figure 2*
International Bodies Concerned With Outer Space

U.N. Bodies



*Dotted lines represent observers. Reprinted from: Proceedings, International Conference on Doing Business in Space. From presentation by Bert Cowlan.



Orbiter Hoisted at Dynamic Test Stand by Arthur Shilstone, watercolor, 29" by 37".

Both Figures 1 and 2 document that the Committee on the Peaceful Uses of Outer Space (COPUOS) acts as the coordinating committee for the General Assembly to manage all aspects of space-related questions. COPUOS is divided into two permanent subcommittees, the Legal Subcommittee and the Scientific and Technical Subcommittee. COPUOS began as an ad hoc committee in 1958 and became a permanent committee in 1959. Of course, it is not coincidental that these dates roughly approximate the initiation of space travel and the so-called "space race" between the United States and the Soviet Union. As might be expected, the workings of COPUOS are very political in nature—especially the work of the Legal Subcommittee—because COPUOS is a public international committee comprised of the official representatives of fifty-one nation-states. In fact, the early years of COPUOS were marked by continual disputes over membership and voting criteria, as well as controversies over the substantive issues of international policy. Nevertheless, the Legal Subcommittee of the ad hoc COPUOS recommended in 1959 that: (1) the United Nations Charter (which includes the Universal Declaration of Human Rights)[7] and the Statute of the International Court of Justice not be confined to Earth, but rather their provisions be extended to include outer space activities; (2) extensive study of the principles and procedures which apply to the sea and to airspace be conducted to determine their relevance to space regulation; and (3) the initial creation of a comprehensive code of space law is impracticable, but a set of general principles which would serve as a basis for subsequent law could be developed in response to the practical problems arising in this new environment.[8]

Following two official General Assembly resolutions and eight years of creative and arduous work, the General Assembly expanded upon the above suggestions by adopting on December 19, 1966 the recommendation of COPUOS for a Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies.[9] The Treaty was opened for signature on January 27, 1967. This "Outer Space Treaty" or "Space Charter" has been characterized by some as a Magna Charta for space. Treaty provisions declare that:

(1) International law and the Charter of the United Nations shall apply to space activities.

(2) Outer space and celestial bodies are the province of mankind and shall be used only for peaceful purposes and for the benefit of all mankind.

(3) Nuclear weapons, weapons of mass destruction, military bases, and military maneuvers are banned from space.

(4) Outer space shall be free for exploration, use, and scientific investigation.

(5) There can be no claims of sovereignty or territory by nations over locations in space, "by means of use or occupation or by any other means."

(6) Jurisdiction over space objects launched from Earth shall be retained by the launching state.

(7) Private interests are recognized as having freedom of action in space, so long as a government or group of governments on Earth authorize and exercise continuing supervision over their activities. Signatory nations (seventy-eight at last count, including the United States and the Soviet Union) are therefore under a duty to oversee the activities of their citizens and commercial ventures in space.

(8) Governments are liable for damage caused on Earth by their space objects.

(9) Astronauts are "Envoys of Mankind" and are entitled to non-interference and all necessary assistance in distress.

(10) The natural environments of celestial bodies should not be seriously disrupted, and Earth must not be contaminated by extraterrestrial organisms.

A process of consensus in COPUOS determined the workings of the Outer Space Treaty.[10] Earlier membership and voting disputes were resolved by establishing a large membership and an agreement process among the members. The agreement process required each member to read a statement of understanding on any perceived agreements into the record, both to assess the degree of true consensus and to preserve each government's unique interpretation of any existing consensus.

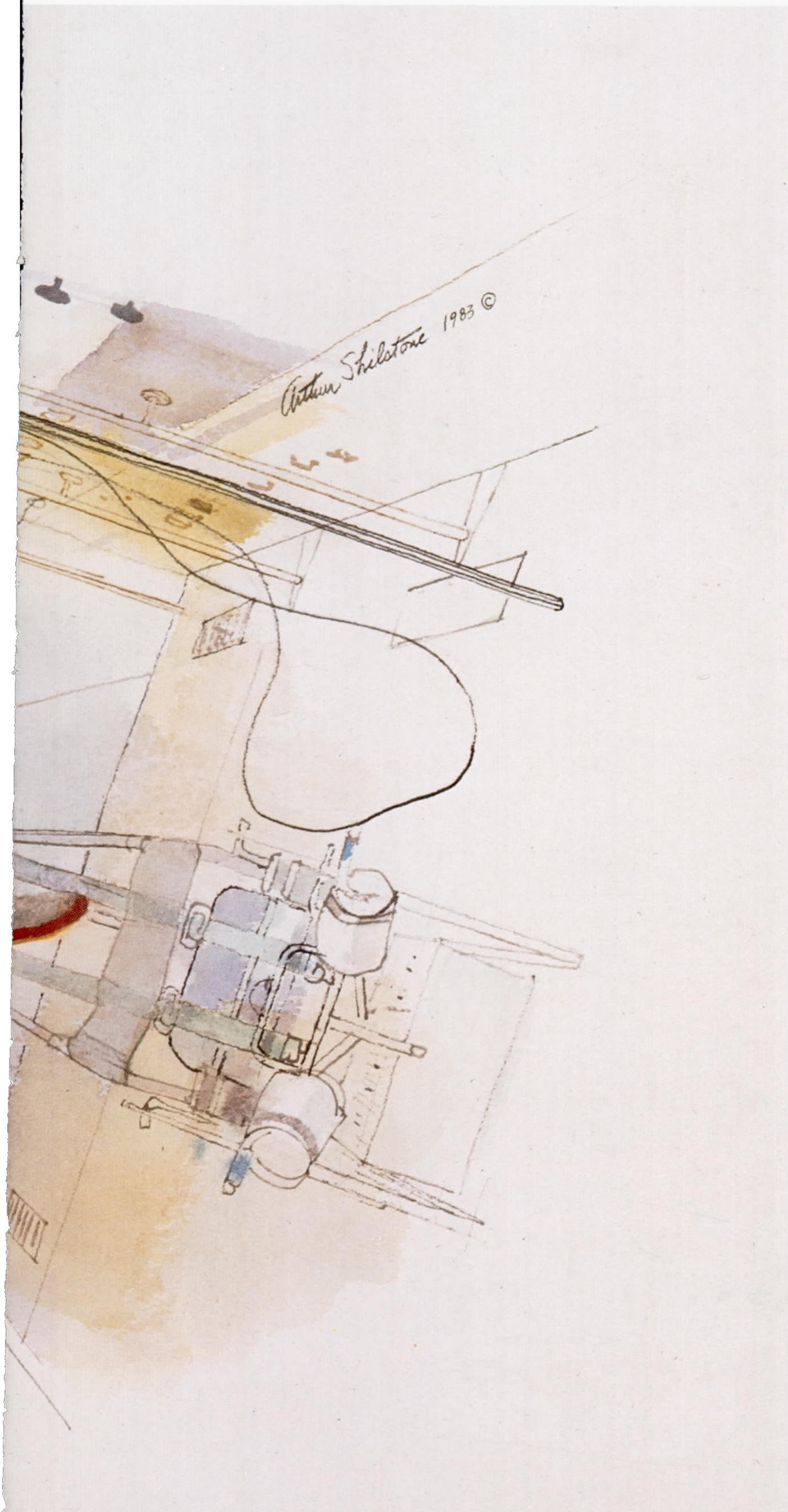
Analysis of the debates, resolutions, and ratifying documents accompanying the Outer Space Treaty confirm its quasi-constitutional intent. The treaty was designed to create a set of overriding principles that should govern subsequent multilateral and bilateral agreements. Indeed, four subsequent agreements have elaborated on the principles of the Outer Space Treaty, and each incorporated the Outer Space Treaty by reference. This type of interrelationship among international treaties and agreements is unusual and further documents the guiding function of the Outer Space Treaty. The four subsequent agreements are: (1) the Agreement on the Rescue and Return of Astronauts, and the Return of Objects Launched into Outer Space, opened for signature in 1968;[11] (2) the Convention on International Liability for Damage Caused by Space Objects (Damage Convention), available for ratification in 1972;[12] (3) the Convention on Registration of Objects Launched into Outer Space, opened for signature in 1975;[13] and (4) the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Treaty), available for signature in 1980.[14]

The Moon Treaty is the only one of the four documents not yet in force; the Secretary General has not yet received deposition of the instruments of ratification by five nations, as required by the treaty itself. The Moon Treaty also represents the only one of the four agreements which became deeply imbedded in controversy immediately upon its resolution of approval by the General Assembly. Some of the more controversial provisions include:

(1) a ban on all weapons (not just nuclear or mass destruction weapons) from celestial bodies, although this provision is not applied to Earth orbit;

(2) a clear prohibition on private ownership of extraterrestrial real estate, or of resources "in place," and a

Astronauts in Spacelab I by Arthur Shilstone, watercolor, 30½″ by 22½″.


Arthur Shilstone 1983 ©

designation of extraterrestrial resources as the Common Heritage of Mankind; and

(3) the eventual establishment of an Outer Space Regime whose authority would be actionable and whose purpose would be to oversee and regulate the "orderly development and exploitation" of extraterrestrial resources.

Despite the accession of the American delegation to the Moon Treaty—and despite the delegation's uncontradicted statement in COPUOS that the words "in place" allow private property rights to apply to resources upon extraction—it now appears doubtful that the Moon Treaty will be presented to the U.S. Senate for ratification in the near future.[15] Private interests in the United States fear that the Outer Space Regime (or space government) will tend more toward a one-nation-one-vote structure than toward the contribution-oriented organization of the World Bank or International Monetary Fund. Many analysts fear that the majority of countries might insist, as they have in the Seabed Treaty negotiations, that this proposed space administration not simply issue licenses without discrimination (perhaps for a nominal fee or small net profit percentage), but also deny or control uses of outer space, levy stiff taxes, and/or oversee equipment use and retrieval in free space.

The previous treaties and agreements are in force, and even though their provisions are not strictly enforceable or self-executing, many nations have complied: NASA sterilized its Mars landers; the Soviet Union compensated Canada under the Damage Convention for the crash of the Cosmos satellite; and the United States expanded the NASA act to extend domestic public jurisdiction into space where permitted by treaty.[16] The active and independent space programs in Europe, Japan, China, and India also consider treaty provisions in planning and operations.

What do these activities portend for supra-national or global government? Despite increasing international interdependence, optimism in the face of all the world's problems is difficult. Indeed, as the debate surrounding the Moon Treaty has evidenced, those living in societies that recognize a significant degree of individual sovereignty may be wise to weigh the value of a precipitous move toward supra-nationalism or global government. Though promising, the call for globalism must be balanced against the need to insure perpetual freedom and fundamental human rights. Moreover, the prospect of global government does not seem to lie in the near future.

Yet, the United States itself was founded on the supra-national concepts of naturalism, which hold that there are certain inalienable rights and natural laws inherent in the whole mental, physical, and moral constitution of humanity. Even the federal government of the United States is supra-national in a sense: recall the reluctance of the citizens of one "sovereign" colony or state to be governed by a President from another "sovereign" colony or state. The Articles of Confederation reflected that reluctance, which was only grudgingly overcome by the rights guaranteed by the U.S. Constitution. Indeed, barely one hundred years ago the United States fought the Civil War over the laws of final authority (each individual "sovereign" state or the supra-national federal government).

Regardless of form, law ideally attempts to express the will and collective judgment of the society it governs. The intent of society may be manifested in basic principles that guide general behavior and inspire future institutions rather than provide specific enforcement mechanisms; three of the most influential documents of human history—the Magna Charta,[17] the Declaration of Independence,[18] and the Universal Declaration of Human Rights[19]—represent excellent examples. The development of ideology and the growth of knowledge often parallel institutional developments, as ideas are embodied in institutions and documents. Although the Magna Charta was barely enforceable after King John left Runnymede, many of its concepts were incorporated six hundred years later into the Bill of Rights to the Constitution of the United States.

In this respect, many observers see the discovery of the New World as a reflection of hopes and aspirations of the Old World. The development of ships, clocks, compasses, and telescopes stimulated a growth in the old supra-national ideas of individual sovereignty and freedom, resulting in democracy and invention. Perhaps in the same way the development of spaceships, computers, relativity theory, and radio telescopes have produced an application of the same age-old ideas into the social complexity and interdependency of international systems.

The space treaties use terms that have never before been considered and that challenge humanity to structure the ideals applicable to space operations. Surely world activities in space will affect the way nations approach each other on Earth. The "world" of space can serve as a mirror for hopes and aspirations; one should not underestimate the power inherent in ideas, even ones that cannot be immediately implemented. The space treaties constitute the first international legal documents to employ the term "mankind" and to affirmatively recognize the (at least) quasi-subject status of non-governmental organizations. Some analysts even suggest that a continued incorporation of the term "mankind" into U.N. treaties might ultimately generate some form of aggregate international standing in international law, perhaps initially third party beneficiary status.

However, now, and for the foreseeable future, the only subjects of international law are the nation-states. Individuals possess no standing under international agreements or before international tribunals. Yet, a subtle shift toward the ultimate subrogation of national sovereignty is evident. For instance, the Nuremberg Trials and the Universal Declaration of Human Rights recognize that there are certain acts that the sovereign cannot or should not commit, such as genocide. However currently ineffectual, certain transnational conventions (such as the Helsinki Accords) embody ideas limiting sovereign action.

Despite the necessarily increasing specificity of space law, some observers note that the *concept* of space law is one of naturalism. Space law considers the welfare of

people as the beginning and end of all human activity and recognizes humans as the holders of fundamental and non-transferable human rights. The fact that the United Nations has elaborated space laws confirms the above statement. The common cycle followed by human beings as subjects of law proceeds from individual to society to state to international community to humanity.

Just humanitatis is the law of and for humanity—it is not international law, which now governs international relations, but rather the law of the human race as a whole, the fourth political dimension of humanity. The Outer Space Treaty repeatedly refers to "mankind" and "people" rather than "states," "nations," or "international community."[20]

Perhaps the future will produce a global sovereignty, and perhaps beyond that a more advanced form of individual sovereignty. We don't know, of course—but we have begun the exploration.

Appendix Two includes a brief discussion of the United Nations' structure and purposes, a suggested bibliography, a list of countries and their adherence to selected treaties and conventions, and a list of relevant international agreements.

Footnotes

1. Final Act of the Conference on Security and Cooperation in Europe (Helsinki, Finland). August 1, 1975. Department of State Publication No. 8826 (Gen. For. Pol. Ser. 298). Reprinted in 14 I.L.M. 1292.

2. Final Acts of the World Administrative Radio Conference for the Planning of the Broadcasting Satellite Service. Geneva: International Telecommunication Union, 1977. (Region 1 consists of Europe, including Asiatic Russia, Africa, and the Middle East. Region 3 consists of the Pacific area and the Far East.)

3. Haley. *Space Law and Government.* 1963, pp. 308-311.

4. See footnote 3, pp. 311-12.

5. Agreement relating to Intelsat, with annex done at Washington on 20 August 1971. Entered into force for the United States Communication Satellite Corporation on February 12, 1973 (TIAS 7532; 23 UST 4091). Framers of Intelsat saw the organization as a form of international commercial cooperative in which governments or their designated telecommunications entities (public or private) could participate.

6. Jasentuliyana. *Manual of Space Law.* Vol. 2, 1979, pp. 427-37. ESA is an intergovernmental consortium of the eleven European Common Market countries and Canada.

7. U.N. General Assembly Official Record (G.A.O.R.), 3rd Session. Resolutions (A/810), p. 71. General Assembly Resolution 217 (III) of December 10, 1948. The preamble is indicative of the theme of the Declaration: Whereas it is essential, if man is not to be compelled to have recourse, as a last resort, to rebellion against tyranny and oppression, that human rights should be protected by the rule of law . . . Whereas the peoples of the United Nations have in the Charter reaffirmed their faith in fundamental human rights, in the dignity and worth of the human person and in the equal rights of men and women . . .
Now, therefore . . . the General Assembly . . . proclaims this Universal Declaration of Human Rights as a common standard of achievement for all peoples and all nations, to the end that every individual and every organ of society . . . shall strive . . . to promote respect for these rights and freedoms, and by progressive measures, national and international, to secure their universal and effective recognition . . .

8. 14 U.N. G.A.O.R. 1 Annexes (Agenda Item 25) 23. U.N. Document A/4141, 1959.

9. General Assembly Resolution 2222. 21 U.N. G.A.O.R. Supplement (No. 16) 18. U.N. Document A/6621, 1966. Entered into force for the United States October 10, 1967 (18 UST 2410, TIAS No. 6347, 610 UNTS 205).

10. Galloway. *Journal of Space Law.* Vol. 3, No. 1, Spring 1979.

11. Entered into force for the U.S. on December 3, 1968 (19 UST 7570, TIAS No. 6599, 672 UNTS 119).

12. Entered into force for the U.S. on October 9, 1973 (24 UST 2389, TIAS No. 7762).

13. Entered into force for the U.S. on September 15, 1976 (28 UST 695, TIAS No. 8480).

14. Draft Agreement Governing the Activities of States on the Moon and Other Celestial Bodies. 34 U.N. G.A.O.R. Supplement (No. 20) 33. U.N. Document A/34/20, Annex II, 1979.

15. U.N. G.A.O.R.. U.N. Document No. a/AC. 105/PV. 203, 1979.

16. Amendments to 42 U.S.C. 2000. Summers 1979 & 1981.

17. Signed by King John I of Britain at Runnymede, England on June 15, 1215. This document represents the first major statement of the responsibilities of the King (then the *only* sovereign) vis-a-vis the citizens. It contained prohibitions against confiscation of private property, unfair taxation, and imprisonment without due process.

18. Enacted by the Second Continental Congress of the newly proclaimed United States of America on July 5, 1776. This document was the first official recognition by a "government" of the inalienable and God-given rights of humanity and was in many ways a successor in interest to the Magna Charta.

19. See footnote 7. Recognizes rights to: life; liberty; equal status before the law; public trial; presumption of innocence; privacy; freedom of movement and emigration; political asylum; marriage; property; ownership; freedom of thought, conscience, and religion; freedom of speech and assembly.

20. Cocca. *Journal of Space Law.* Vol. 13, Nos. 1 and 2, 1981.

Philosophy

Advances in Scientific Knowledge and Implications for Philosophy

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I. Introduction

Space has deeply affected philosophy as the study of the truths or principles underlying all knowledge and being (or reality). The earliest writings of ancient Greek fathers of Western philosophy reflect a concern for the haunting environment that lay overhead. The complex and symmetrical star patterns in the night sky, repeating with precision generation after generation, could not but stimulate the more curious and intelligent members of the robust Greek society. Nature included the night sky, but its qualities seemed different from those of Earth. The vastness, inaccessibility, symmetry, and permanence of the night sky made it a natural topic for philosophers pursuing an understanding of ultimate reality and of the divine. Space continually has animated the study of epistomology, logic, cosmology, metaphysics, and theology.

Until recent centuries, the inherent intertwining of philosophy and science resulted in leading practitioners in one field often being equally credentialed in the other (Aristotle represents the prime example). The Greeks bequeathed a view of a limited and harmonious universe, driven by a "prime mover."[1] This major philosophical paradigm permeated the conduct of cosmology, metaphysics, and theology in Western society for more than 1500 years.[2]

The scientific revolution of the 16th and 17th centuries brought the solar system into the domain of Newtonian physics, and many observers presumed that this concept constituted the Rosetta Stone for the entire universe. Although "first cause" still occasioned speculation, philosophers and scientists considered the problems of time, space, and matter as largely solved. Precise observation and application of gravitational mechanics could determine the structure of the universe at any given time in the past or future.

The cosmological confidence of the Newtonian world collapsed with the stunning achievements of Max Planck, Albert Einstein, Werner Heisenberg, and other scientists during the early part of the 20th century. Science redefined the problems of time, space, and matter—and the fundamental problems in epistomology arose once more, making the overall structure and future of the cosmos a continuing subject of debate.[3]

Throughout the ages, developments in instrumentation have affected and often stimulated changes in philosophical perspectives related to space. For example, perhaps most fundamentally, the invention of the telescope in 1610 permitted astronomers to observe much more of the information about space reaching Earth through visible light. The discovery of so many new stars with the telescope prompted philosophers to conclude that the naked eye could perceive probably only a small fraction of the universe. This conclusion contributed to the dialogue on the finite or infinite nature of the universe, with the many philosophic implications that debate entailed.

The advent of spectroscopic analysis of the light from celestial bodies provided the first clues to their actual physical and chemical composition; the upshot was the understanding that the Sun is essentially just a medium-sized star with a very ordinary history and future. This observation stimulated lead thinkers to consider the fact that nothing distinguished the local space environment as distinctive from a cosmological perspective.

The rise of relativity theory and quantum mechanics produced the 20th century revolution in perceptions of cosmological physics. Moreover, these developments have been accompanied by a revolution in instrumentation that generates information about the cosmos not only from visible light, but also from radio waves and microwaves, infrared and ultraviolet light, and X-ray and gamma rays. Known in the aggregate as electromagnetic radiation, these waves and rays offer a more varied view of the universe than only visible light. The universe becomes a much more complex entity, exhibiting powerful phenomena and processes that function on planes of reality well outside our ordinary frame of reference.

Visible light and radio and radar waves constitute the only elements of the electromagnetic spectrum that reach the Earth's surface. The Earth's atmosphere impedes observations of other spectrum components. Following

World War II, astronomers began to monitor radio waves from space to supplement research via radio telescopes.

The initiation of the space program in the late 1950s enabled astronomers to observe the full range of the electromagnetic spectrum free from the shielding effects of the Earth's atmosphere. The first satellites launched by the U.S. space program in 1958, Explorers One and Two, carried instruments to measure general cosmic radiation, as did the Mariner and Pioneer interplanetary probes in the early and mid 1960s. NASA later initiated the Orbiting Astronomical Observatory program, designed largely to study the ultraviolet regions of the spectrum. In the early 1970s, NASA launched satellites equipped to detect extragalactic sources of X-rays; in the late 1970s, satellites began observing gamma ray emissions. These satellites contributed a great deal to the development of a more comprehensive and sophisticated understanding of the cosmos. Scientists detected new phenomena (e.g., quasars) and, more importantly, the view of the universe as a serene collection of stars and galaxies gave way to a picture of a universe characterized by violent and cataclysmic events.

The Shuttle's large carrying capacity permits NASA to place large satellites in orbit during the 1980s, including the Space Telescope and the Gamma Ray Observatory. Such satellites should exploit more fully the electromagnetic waves in the Earth's vicinity and penetrate more deeply the astrophysical reality of the universe.

Given the objectives of astrophysical research in general, any significant change in the scientific understanding of the universe clearly will produce an impact on the philosophical perception of the relationship between Earth (and its inhabitants) and the universe. As a consequence, humanity's conception of itself will change as well.

The literature documents a well known and intimate—if not always apparent—linkage between Plato's or Aristotle's views of humanity and the closed universe of the Greeks and the views of Galileo, Descartes, or Pascal and their perceptions of an infinite universe so radically different from that of the Ancients.[4]

In like manner, the current concept of a universe expanding as the result of an initial big bang has significantly modified human beings' self-conceptions and views of the world's relation to the rest of nature. Some observers believe that the ratio of fundamental physical constants during the first instants of the present universe opened a narrow window in the energy spectrum for the emergence of life, consciousness, and intelligence and generated energy emissions that can move no faster than the speed of light. These emissions thus require considerable time to travel cosmic distances—which, in a manner of speaking, permits the universe to look back on itself.[5]

This fundamental linkage between purely physical events and the emergence of intelligence raises a number of properly philosophical issues. The significance of these issues in the context of NASA's space exploration program lies in the all-pervasive effect of a priori attitudes on both the way issues and problems are analyzed and, more generally, the cultural characteristics of society.[6] Thus, policy decisions and the role of science in such decisions are determined in part by society's philosophical concerns.

The impact of the space program in general and the Space Shuttle in particular on college-level philosophy curricula will be most pronounced in those courses that focus on the nature of humanity and on the impact of science and technology on society (and, to a lesser extent, on the relation between science and technology in general). Each is discussed briefly below.

II. Nature of Man

Philosophical discussions address primarily two distinct conceptions of human beings, which may be labelled, for the sake of simplicity, the "dualist" (or two substance) theories and the "materialist" (or one substance) theories.

The two substance theories posit that each human is a composite of two radically distinct substances, mind and body, each possessing essential features which are irreducible to those of the other. Descartes represents perhaps the best known proponent of this view, although it can be traced to the writings of Plato and to even earlier works.

One of the principal advantages of this dualism is the provision of a separate basis for the moral nature of humans; the mind appears as the moral core of the composite, governed by laws that differ from those that control matter. By the same token, this view justifies the beliefs that humans are not simply ordinary objects or animals to be treated on a par with the rest of nature and that conflicts between values are resolved in favor of intrinsic human values (rooted in mind or soul) over utility or other socially defined goals. Seen in this way, the rest of nature may be classified as morally neutral, whereas humans are endowed with a moral conscience and, consequently, with inalienable rights that support the ideals of Western democracy as well as procedures such as the Nuremberg trials. This view should not be construed to suggest that a materialist theory necessarily would be incompatible with a doctrine of "intrinsic human rights," but rather to indicate that a dualist view makes such a conclusion much more "natural" and consonant with the whole cultural tradition rooted in classical Greece and later reinforced by Hellenized Christianity.

On the surface, materialist theories of mind correspond more fully with the evolution of nature, since the materialist theory takes for granted that the mind, like all forms of life, results from the evolution of the material universe. As such, this theory largely rejects the view that values in general and moral values in particular are irreducible to the "laws" that are said to govern inanimate matter. Specifically, such views naturally support the notion that the individual can be totally reduced to social relations (humans as social animals), that each human represents a nexus of such relations without any residual or non-reducible core (so-called "organization" or "totalitarian" Man). Although values can be "emergent" in the evolutionary process, in a conflict of values, "social" ones tend to take precedence

When Thoughts Turn Inward by Henry Casselli, watercolor, 26" by 32".


Space Shuttle
"when thoughts turn inward"

over individual or intrinsic ones. To put the matter differently, there is no obvious way to ground the inalienable rights of the individual (upholders of such rights are seen as dissidents or anti-scientific). Society, the Human Race, the Eclesia, and the People constitute the main fact, and the individual becomes a totally dependent and consequently ancillary element of the whole.

The space program likely will sharpen awareness of the fundamental unity of nature and of humans as a natural development of the same natural forces responsible for all cosmic activity. Thus, the space program can help focus attention on the uniqueness of each human as an individual and on the individual's relation to society and the rest of nature, thereby reinforcing a current of thought already extant in the life sciences.

In addition, the materialist view of mind and matter probably will be considerably reinforced by the rapid advances in artificial intelligence that inhere in the success of the space program; new machines capable of reproducing intelligence on a vast scale and with far more sophisticated methods will constitute essential components of future space exploration. The development of such machines clearly raises the question of the criteria necessary to justify mind and matter as radically distinct entities.

Not unexpectedly, any development that clarifies the relationship between the process of human evolution (including consciousness and intelligence) and the so-called "blind forces" of nature also will sharpen the issue of the relationship between individual humans and society. To the extent that the space program influences the evolving notion of Man, the program will assume philosophical significance by exerting an impact on the view of the individual's role in society.

The impact of the space program on philosophy would take two basic forms. In the first case, space activities would reinforce a number of classical and modern views which contend that each human's value results from the function served in society. In an extreme form, this view considers humans alone as nothing more than simple animals without intrinsic value.[7] Here, the space program would predominantly influence social and political philosophy. In the second case, the space program would raise more sharply than ever the question of the nature and role of values, for example, whether values bespeak some transcendent nature or are reducible to mere ordinary facts. If values are reducible to natural phenomena of the sort described by the physical sciences, then individuals no longer possess intrinsic value, but acquire value in proportion to societal utility, however defined.

In addition, the nature of values (e.g., aesthetic, moral) and the mode of value determination will become central in this context. Therein probably lies the seed of cultural and, consequently, of philosophical revolution. The perceived relationship of Man to the rest of nature will constitute the main determinant of this cultural change.

Relatively little material is published on the issue of the moral foundation of humans, but a course of lectures could be used to define or refine the problem. Such a course would be divided into roughly five segments that address:

(1) the dualist view of humanity, with appropriate readings from Plato, Descartes, Locke, and the more recent dualists;

(2) the monist theory of humans, with readings from Hume and the more recent materialist school writers, both in the Marxist and the Western traditions;

(3) the view of science, with readings on the origin of the universe, the evolution of the cosmos, the origin of life on Earth, and the evolution of humans and society;

(4) the so-called "naturalistic fallacy" and the question of the reducibility of values to characteristics of nature, with readings on the foundations of values; and

(5) the open question: are the two major lines of development of Western civilization—i.e., the reductionism of the scientific enterprise and the assertion of the Rights of Man—compatible or antithetical? Readings could be drawn from the Greek period, the eighteenth century, and the twentieth century and could encompass fields such as anthropology, history, political philosophy, the theory of knowledge, and science and freedom.

III. Relation Between Science and Technology and Its Social Implications

Science aims for the total reconstruction of nature in fully intelligible terms, essentially depending on the available means to observe nature under various conditions. Herein lies the source of science's dependence on technology, for technology provides the scientist with the sophisticated means of probing regions and phenomena far removed from the ordinary or natural domain of human experience.

The import of this dependence stems from the reliance of theoretical concepts and functions on observables. Consequently, the meaning or significance of observations rests heavily on theories (both the general theories being tested and theories of observation); in an important sense, "seeing" is "seeing as."

Furthermore, when sophisticated instruments conduct all observations, "seeing" is accomplished without the operation of "natural intuitions" to sort out the probable from the improbable. A corresponding "intellectualization" of experience results (this is apparent whenever the scientist contemplates the reaction of the proverbial man-in-the-street when confronted with the data provided by instruments). The progressive uselessness of common sense experience in evaluating complex data—an inevitable concomitant of the intellectualization of observation—eventually produces a corresponding disregard for intuitions as a guide to action. For example, intuitions may be contradicted by medical advice in cases of personal health, leading more generally to the abandonment of "unreliable" common sense instincts. As a developing social characteristic, this abandonment of intuition opens up a whole range of possibilities for manipulating people in a democratic society, by relying on their credulity and playing on both their ignorance of scientific matters and

the unreliability of their common sense intuitions. This development is fraught with dangers and opportunities and raises the question: do humans have a "right to know the truth of the matter," or not?

The essential role of technology in the formation of world views and the resultant intellectualization of perception may facilitate the progressive widening of the gulf between the so-called "second" and "third" worlds from the advanced countries. Such a gulf relegates less developed peoples to the cultural backwaters and quicksands, with no obvious means of escape, save for a relatively few individuals. This alienation process is becoming more pronounced as space technologies and related conceptual frameworks stimulate new forms of activity (e.g., communication satellites and teleinformatics). Noticeable effects of this process already appear in a number of international cooperation and aid programs designed to "close the gap." On a more global scale, the rise of fundamentalist sentiments in large sections of the world—as well as conscious regressions to various forms of irrational thought such as magic, mysticism, mysteries, and reliance on drugs—appear to be spurred by the rapid rise of the new scientific and technological culture. This uneven evolution of the world's human cultures poses a number of troubling philosophical questions with import for social and political thought, as well as for philosophical anthropology. This development may well revolutionize these disciplines (and others as well in an academic "trickledown").

Appendix Two provides a brief bibliography and information on a team-taught course that incorporated space issues into the study of philosophy.

Footnotes

1. S. Sambrusky. *The Physical World of the Greeks.* New York: Macmillan Co., 1956.

2. Alistair C. Crombie. *Augustine to Galileo, The History of Science, A.D. 400-1650.* Cambridge, MA: Harvard University Press, 1953.

3. Milic Capek. *The Philosophical Impact of Contemporary Physics.* New York: D. Van Nostrand Co., 1961.

4. A. Koyre. *From the Closed World to the Infinite Universe.* Baltimore, Maryland: Johns Hopkins, 1957. Also: P. Duhem. *Le Systeme du Monde.* Paris, France: Hermann, 1959, Vol. W.

5. John A. Wheeler. *How Did the World Come Into Being?* Proceedings of the Fifth International Conference of Logic, Methodology, and Philosophy of Science. Ontario, 1977.

6. Thomas S. Kuhn. *The Structure of Scientific Revolutions.* Chicago, Illinois: University of Chicago Press, 1970.

7. *Brave New World* and *1984.*

Political Science

The Politics of Space: Understanding Space Policymaking

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I. Introduction

The business of government is the making of decisions—decisions that authoritatively allocate advantages and disadvantages for an entire society. Politics represents the process of government decisionmaking (rather than having choices made by the market or by some other institution such as religion). The decisions of government officials range from the mundane to the fundamental. If decisions about policy—i.e., what course of action to follow—indeed constitute the central activity of government, then the study of those decisions and the selection process preceding them should be a primary concern of political scientists.

As an area of government activity, the U.S. space program has been prominent for a quarter century. The government has made and implemented numerous decisions about the objectives, pace, and management of various elements of the U.S. space program, and policymakers continue to address and resolve many such concerns. (The focus on government decisions does not deny the importance of diverse private sector space-related decisions, but until recently the government-sponsored activity dominated the U.S. space program.) Political scientists have developed a variety of approaches to understand and analyze the policymaking process, and such methods can be applied directly to comprehending the formulation of space policy.

Unfortunately, the public policy decisionmaking process is extremely difficult to study. Space policies, particularly those of highest significance, are determined within the executive branch of the government, often without public or even Congressional participation. President John F. Kennedy once argued that the factors that influence the most prominent national policy discussions never could be completely understood: "There will always be the dark and tangled stretches in the decisionmaking process—mysterious even to those who may be most intimately involved . . ."[1]

How, then, can one understand and explain a government action in any specific policy situation? Political scientists can claim some success in developing theories that interpret the behavior of various actors and institutions in the American political process. For example, the determinants of voting behavior have been identified, the influence of Congressional committees analyzed. The many Presidential roles have been studied, the limits on Presidential power discussed. In short, political scientists can speak with some confidence about the determinants of the general behavior patterns of the most important elements of the political system. However, with only a few exceptions, political scientists have not yet developed theories that can verify with any degree of confidence why a policymaker implements specific action or crafts a particular decision. This point needs emphasis. To contend that a President usually acts to preserve his professional reputation and public prestige is a plausible theory[2]; to suggest that these considerations represent the primary factors that determine Presidential action on a specific issue is quite another hypothesis—and much more difficult to prove.

Yet there is no shortage of often conflicting explanations of particular governmental decisions in both the foreign and domestic spheres. If a political scientist cannot rely on extant theories to produce a high degree of confidence in those explanations, how can improved theories be developed? How can an analyst assess the motivations behind a specific policy decision?

For political scientists, an important distinction is drawn between description and explanation. A historian might be interested in describing the myriad events associated with a particular decision and perhaps preparing a narrative that details the policymaking process; however, a political scientist probably would attempt to interpret the relationship between those events as causes and the decision as effect. The following discussion illuminates the way political scientists go about this job, i.e., how they relate causes in the space policy decisionmaking process to a specific policy outcome.

II. Conceptual Frameworks for Decisionmaking

Since political scientists do not possess any verified theory of decisionmaking, they generally explain a policy

4th of July Return by Bill Robles, acrylic, 32″ by 25″.

choice in much the same way we all explain the world. Humans are bombarded constantly with sensory stimuli and various forms of information. These inputs constitute the data base for assembling an understanding of the world and the relationship of individuals to the world in which they live. Raw data are processed by the nervous system and brain and assembled into images and insights that are interpreted in the context of past experiences and education. This processing is accomplished with the help of filters and models. Filters screen out some data as irrelevant or unnecessary and permit other more useful bits to be absorbed. Models help integrate these disparate data bits into a coherent analysis that makes sense (to the sane) and provides an understanding or insight into the world and its functioning. The whole process of formal and informal education throughout a lifetime serves as a means to develop more sophisticated, useful, and realistic filters and models to help the individual relate to the world. Education ceases when these filters and models become incontrovertibly set—an event that unfortunately occurs too early for too many people.

The analyst who explains a particular policymaking process and the resulting decision employs a process analogous in many ways to the one just described. An almost endless amount of data is potentially relevant to the explanation. For example, the capabilities, actions, and intentions of other nations often affect policy choices. The milieu of other events surrounding the decision process may well provide an influential context. Each participant in the process applies a set of personal characteristics and values that may be important. Prior rivalries of a personal, organizational, or national nature may be significant, and so on. Obviously, it is humanly impossible to prepare a complete "state of the world" description of each decision process that contains all the information potentially relevant to an explanation of the resulting policy.

When an analyst confronts too much potentially relevant data, that analyst must use some method to select pertinent data and determine which questions to answer. The criteria for this winnowing process are contained in an implicit or, more frequently, an explicit conceptual framework or model of how and why policy decisions are generally made. Such a model performs the function of filtering and organizing the raw data basic to understanding the decision. Like the filters and models of the human mind, the conceptual framework used by the policy analyst serves as a tool that permits the separation of the relevant from the irrelevant, the important from the trivial, the unexpected from the routine. Such frameworks or models are not theories; the constituent variables and relationships have not been verified empirically. If the models could be proved, they might become theories; however, even without theoretical status, such models constitute a necessary starting point.

No one conceptual model of policymaking is "best" or "correct" in the view of most political scientists. Rather, a variety of such models exists, and several typical models are reviewed in the next section. Of course, the use of different models may and usually will explain the same decision differently. In the absence of a verified theory of policymaking, no one model can provide a totally accurate or completely reliable explanation of a particular decision. This constraint probably would not stop lay observers from thinking they understand the factors that drive a given decision, and professional policy analysts frequently aren't inhibited either. Yet, if an explanation is not independent of the model used to develop it, and if different models produce different explanations, how can one determine whether a particular explanation is "right?" Quite simply, one can't.

Because the major concerns of political scientists include the study of policymaking, it is not surprising that political scientists have developed a wide variety of conceptual models to analyze policy decisions. In aggregate, the models incorporate a multitude of factors conceivably related to the policy behavior of a nation-state. Political scientists see potential influences on policy variables ranging from the overall distribution of world power to the psychological traumas of childhood. James Rosenau[3] suggests that all such variables can be grouped into five broad influences:

(1) Individual, or the characteristics (e.g., values, talents, experiences) unique to a particular decisionmaker. John Kennedy's activist orientation represents an example of such a characteristic.

(2) Role, or the officials' behaviors that are associated with the roles or positions occupied. For example, the behavior and priorities of the NASA Administrator are likely to differ from those of the Secretary of Defense.

(3) Governmental, or those aspects of a government's structure that condition or influence the choices of decisionmakers, such as the Constitutional separation of powers in the United States.

(4) Societal, or the nongovernmental aspects of a society that influence its policy choices, for example, the pragmatic nature of American culture or the power of American business.

(5) Systemic, or factors external to a country that affect decisions made by that country's officials. Examples of variables in this category include geographical constraints and other countries' policies.

Rosenau's categories constitute only one way of listing factors potentially relevant to understanding a specific policy decision. Political scientists disagree over criteria for identifying the factors most relevant to explaining the selection of any given policy. Additionally, political scientists argue over adaptations of decisionmaking models to treat such factors as causes and policy as effect.

One particularly influential class of models, collectively known as the decisionmaking approach, posits a causal relationship. Such models focus on the process that produces a policy decision as a means of explaining why that decision was made. These decisionmaking models have been used to discover how officials actually responsible for setting policy go about their task. This approach reconstructs the world at the time of decision from the policymakers' perspectives. Analysts using the decisionmaking approach attempt to explain why decisionmakers select one particular course of action from the many

potentially available options. Such analysts emphasize decisionmakers' interpretations and evaluations of the multiple factors that influence both the policymaking process and officials in that process.

One also can describe decisionmaking as a rational process that enables a decisionmaker to: rank objectives in order of priority; identify various means of achieving those objectives (i.e., policy alternatives); gather as much information as possible about the benefits and costs of each alternative, including the costs of not pursuing other alternatives (opportunity costs); and then select the policy alternative that offers the best combination of maximized benefits and minimized costs.

By viewing policymaking as rational and calculated, the analyst can avoid factors such as personal idiosyncracies or organizational politics, since these do not exert an important influence on policy choice (almost by definition). This approach simplifies the explanatory task significantly. For the past thirty years scholars have debated whether the benefits of such simplification are outweighed by the distortions introduced by excluding or minimizing other variables. Those questioning the validity of the rational decision model point out that severe obstacles to rational choice are inherent in almost every decision situation. These obstacles arise largely from the fact that policies are not produced by a single, omniscient, and totally objective decisionmaker, but by numerous decisionmakers with limited information, often conflicting goals, and competitive policy preferences.

Another decisionmaking model springs from the conviction that "policymaking is politics," to quote one student and practitioner of decisionmaking.[4] To analysts who concentrate on the political aspects of decisionmaking, policy is not primarily a product of calculated choice, but rather of a political process, because officials share power and "differ about what must be done. The differences matter."[5] The process of reaching agreement on appropriate policies is characterized by bargaining, compromise, and influence, rather than by calculation—i.e., a political process.

Scholars applying this method give particular emphasis to variables internal to the government (those in Rosenau's individual, role, and governmental categories) as determinants of policy choice. These scholars address questions such as: Who participates in the decisionmaking process? What organization and group affiliations do they have? What power do they possess?

III. Using Models to Analyze Space Policymaking

Each model described briefly above can be expanded, and pertinent research questions for each model can be identified:

A. A Rational Decision Model

Analysts employing this model assume that the best way to explain governmental decisionmaking behavior is analogizing to the behavior of a "rational" individual seeking the "best" means to achieve goals or solve problems. The government thus simulates a unified actor choosing policies according to a procedure incorporating the following steps:

(1) The government perceives and defines a problem.

(2) The government specifies goals and objectives relevant to solving that problem and ranks them in order of relative importance.

(3) The government lists alternative policies for achieving specified ends.

(4) The government identifies the consequences, both favorable (benefits) and unfavorable (costs), that result from each policy alternative.

(5) The government selects the alternative with the best mix of costs and benefits over the whole range of relevant goals.[6]

To the political scientist using this model, policy explanations focus on the goals the government served when choosing a particular policy and on the degree of reasonable correspondence between that policy and the nation's objectives. For the model to analyze a particular policy choice, the political scientist needs answers to the following questions: (1) What national interests, goals, and objectives were relevant? In what order of priority? (2) What alternative courses of action did the policymakers examine? (3) What benefits and costs were predicted for each alternative examined?

When employing this model as an explanatory tool, the political scientist must not inject personal preferences or evaluations of alternative policies; the goal is to interpret the policymakers' analysis of a particular policy as the best and most rational choice. Of course, the model also encompasses normative implications, exposing the calculations of decisionmakers to broader criticism.

In the rational model, then, political scientists portray government as a purposeful, calculating actor, and government behavior in a specific instance is explained by knowing the purposes and calculations underlying that behavior. The central hypothesis of this model contends that a government will choose a policy designed to generate the best possible mix of maximized gains and minimized costs within the context of a particular set of objectives and in a particular decisional situation.

B. Incremental Bargaining Decision Model

Political scientists applying this model classify government policy as the result of a process characterized by "bargaining along regularized circuits among players positioned hierarchically within government."[7] Decisions are made not by one calculating decisionmaker, but by a process of interaction among various organizations and political actors. This process exhibits four characteristics:

(1) Each particular problem or situation encompasses diverse goals and objectives which must somehow be reconciled before a final decision.

(2) Groups of people within and outside government (sometimes associated with particular organizations, sometimes with membership cutting across organizational lines) support each alternative goal or objective and/or each alternative policy.

(3) Power, measured in terms of the ability to influence the outcome of a decisionmaking process, is

unequally distributed among these interested groups.

(4) The final policy is determined as much by power relationships as by the calculated interrelations between means and ends, policies and goals. Thus, policy is selected by the interaction of analysis and the "play of power."

In this model, power constitutes a primary determinant of policy choice; consequently, this decisionmaking process is a political one. Policy results not from a rational calculation, but from conflict and cooperation, compromise and consensus-building among actors holding positions within and outside of the government and performing in accordance with a set of rules. These rules place high value on reaching a compromise agreeable to all parties actively involved in the process; the result is a "strain toward agreement."[8]

A policy produced by such a process is unlikely to differ significantly from policies that previously commanded agreement from relevant groups or officials. Thus, policy changes are usually incremental, representing only small shifts from earlier policies, and longer-range goals and objectives are pursued by a series of such incremental adaptations of existing policy.

Political scientists using the incremental bargaining decision model need to answer the following questions:

(1) Who participated in the decisionmaking process? What official positions did participants hold?

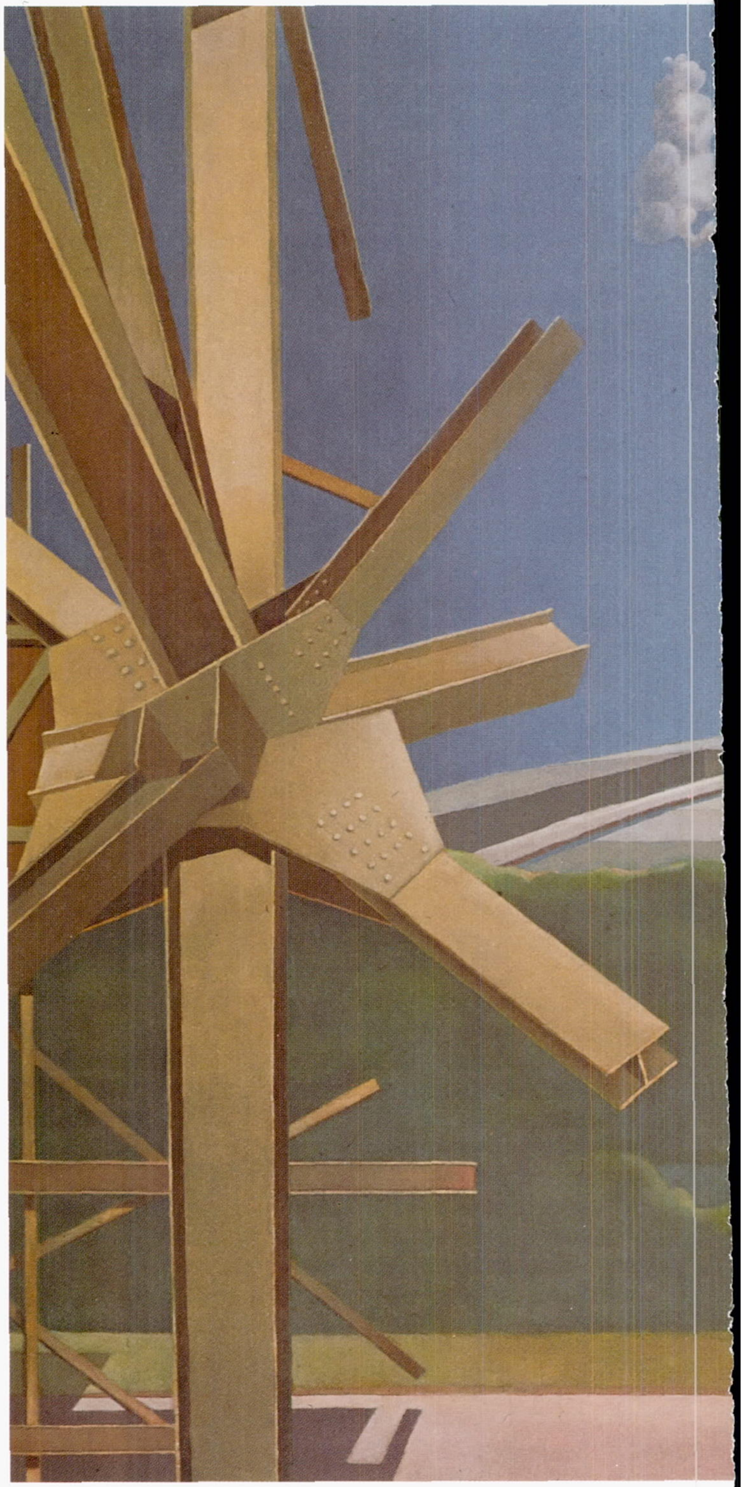
(2) What combination of national, organizational, group, and personal interests determined each participant's policy preferences?

(3) What factors influenced each participant's relative power?

(4) How did participants' policy preferences and their power relations combine to produce a decision? What was the structure of the policymaking process and under what rules did it operate?

Answers to this set of questions require more extensive information than the responses to the questions posed by the rational decision model. Details on the policy preferences of different government actors on a particular issue are not readily available, and evidence relevant to the sources of these preferences is even harder to find. Documents seldom record the dynamics of the bargaining process that generated a decision; for example, to fully answer question four, analysts frequently must interview participants. To piece together an account of a particular decisionmaking process using this model, the analyst must sensitively and skillfully combine and interrelate data from a wide variety of sources.

To summarize, in the incremental bargaining decision model a policy decision is seen to result from bargaining among individuals and groups. The selected policy likely will differ only incrementally from earlier policies. A decision is explained by: describing the structure of the decisionmaking process; identifying the participants in that process; specifying their preferences; detailing the sources of those preferences; and analyzing the "play of power" and contending calculations within the process that produced the decision.



Space Port by Alfred McAdams, oil, 36" by 56".

ORIGINAL PAGE
COLOR PHOTOGRAPH

IV. Space Policy as an Area for Study

Analysts can employ the two general classes of decision models discussed above to study a number of past, current, and future decision situations. For example, the following decisions can be plausibly explained using either the rational or the incremental bargaining decision model:

(1) establishing NASA in response to Sputnik;

(2) committing to a manned lunar expedition as a national goal;

(3) choosing a particular approach—i.e., the lunar orbit rendezvous—to accomplish the Apollo mission objectives; and

(4) rejecting another Apollo-like program aimed at manned planetary exploration (1969-70 time frame).

Political scientists also can review other major decisions in the history of space policy from either perspective.

Furthermore, decisionmaking models can be used as frameworks for understanding current policy debates on various space-related issues, including those connected with Shuttle development. In this application, the models would guide the collection of data useful in understanding both the context of a policy debate and the substance of the issue(s). Analysts can employ decisionmaking models to study a variety of policy controversies, including:

(1) the future of the planetary exploration program;

(2) attempts to muster support for the solar power satellite concept;

(3) the maintenance of support for the Space Shuttle in the face of schedule slippages and cost overruns;

(4) appropriate goals for military space activities;

(5) federal involvement in space activities with commercial potential, such as space manufacturing;

(6) the U.S. position on ratification of the U.N. Moon Treaty;

(7) the development and organization of an operational satellite remote sensing system for the United States;

(8) attempts to focus attention on the concept of space colonies;

(9) the relation of space activities to U.S. foreign policy interests vis-a-vis Europe and/or Japan;

(10) the use of space technology as an instrument of the U.S. foreign assistance program;

(11) proposals by Comsat General and other firms to establish a new direct broadcast television service in the United States via satellites;

(12) controversies over the application of military-derived technologies to civilian space projects.

Finally, analysts can use decisionmaking models as tools to understand space policy as a basis for constructing scenarios about future policy choices. For example, one could focus on: the conditions that would favor a major new space project based on the success of the Space Shuttle; the resulting easy access to space and flexible capabilities for in-orbit operations; and the factors influencing approval of such a Shuttle follow-on project. Using the two decisionmaking models outlined above would sensitize an analyst to the wide range of factors that would determine the political feasibility of such an occurrence.

Appendix Two includes the syllabus and research assignments for a course that used the approach outlined herein, as well as additional insights from two experienced instructors.

Footnotes

1. John F. Kennedy in his foreword to: Theodore C. Sorenson. *Decision-Making in the White House.* New York: Columbia University Press, 1963.

2. This is the argument of: Richard Neustadt. *Presidential Power.* New York: John Wiley & Sons, 1960.

3. James N. Rosenau (ed). *The Scientific Study of Foreign Policy.* New York: The Free Press, 1971, pp. 108-109.

4. This is the title of the first chapter of: Roger Hilsman. *To Move a Nation.* Garden City: Doubleday and Co., 1967. See also: Roger Hilsman. *The Politics of Policy Making in Defense and Foreign Affairs.* New York: Harper & Row, 1971.

5. Graham T. Allison. *Essence of Decision: Explaining the Cuban Missile Crisis.* Boston: Little and Brown, 1971, p. 145.

6. This conceptualization of the classical model of rational decision-making is taken from: Charles E. Lindblom. *The Policy-Making Process.* Englewood, N.J.: Prentice Hall, 1968, p. 13. Lindblom is the primary proponent of the incremental model of decisionmaking, particularly as it applies to domestic politics. The fullest statement of his argument is in: David Braybrooke and Charles Lindblom. *A Strategy of Decision.* New York: The Free Press, 1963.

7. See footnote 5, p. 144.

8. This model is drawn from the writings of Lindblom, Hilsman, and Allison (cited in footnotes 6, 4, and 5, respectively).

Psychology

Orbital Human Factors

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I. Introduction

One of the many secondary outcomes of the manned space program is the stimulation of the behavioral and social sciences toward greater precision in predicting human behavior.[1] Prediction of human behavior long has served as the basic disciplinary conversation of psychology, which makes this topic of inquiry particularly amenable to scientific study.[2] This secondary impact of the space program is a consequence of the requirement to understand human needs and behaviors during space operations. The study of this subject is designated by the term orbital human factors (OHF).

The near-term state of space technology dictates that the human presence in space will be confined to vehicles and facilities that permit only limited physical movement and separate individuals from the broader community of family and social relationships. The Space Shuttle and even the proposed orbiting Space Operations Center (SOC) will be relatively small facilities which become the entire, if temporary, world of the astronauts or space workers on board. The length of space duty will vary from a few days to a number of months and will be roughly analogous to living in the space available on an airliner for lengths of time comparable to ocean voyages in previous centuries. Because of the relatively high expense of placing and supporting people in space, planners have a strong impulse to maximize space personnel work performance. A breakdown or a mere slowdown in work performance can produce dramatic effects on overall mission success.

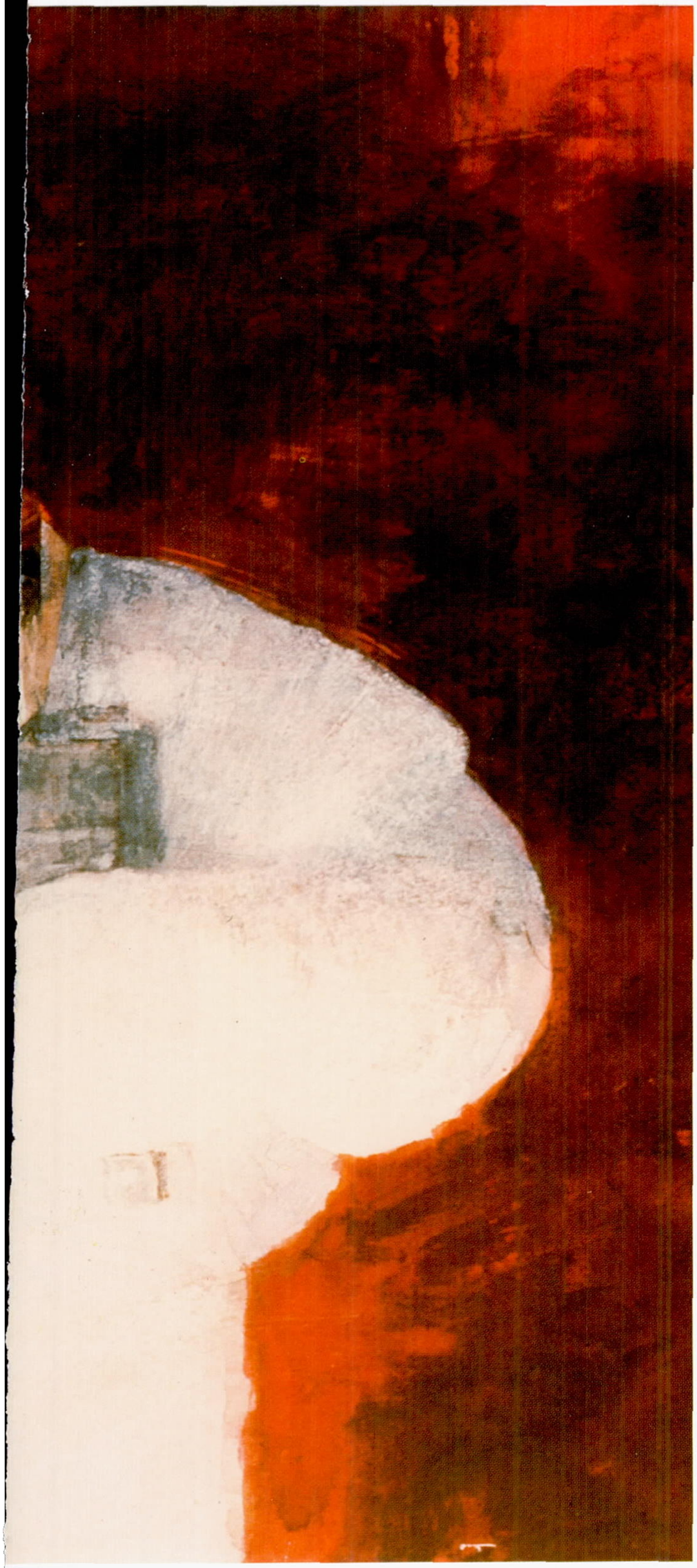
In the early days of the space program, only a handful of people actually ventured into space. These pioneers were test-pilot astronauts who tried out the machinery and confronted the space environment for the first time. The small number of required people combined with the large pool of high-quality applicants to produce a cadre of outstanding individuals. The early astronauts demonstrated extraordinary abilities and commitment and received a high degree of social reinforcement from media attention. These characteristics allowed NASA planners a certain latitude to assign heavy workloads with a high assurance of success, even under occasionally high-stress conditions. However, in the future this latitude will disappear as the type of human presence in space changes. Missions will become repetitive, thus losing both their novelty and the intense media attention that stimulated the accompanying strong social reinforcement. As a discipline, psychology will need to carefully and thoroughly address the possibility of self-generated reinforcement strategies that can be taught to crew members to enhance their sense of personal and professional accomplishment. Indeed, this question of self-directed behavior and reinforcement already has been addressed in psychological literature.[3]

In comparison to earlier missions, work assignments on the Shuttle or the SOC will require greater divisions of labor and more diverse types of personnel on board. Such mission characteristics also influence recruitment standards, which must focus on candidates whose primary credentials lie in professional capabilities to undertake scientific research, skilled labor activities, or management functions (rather than spacecraft flight operations). This diversification of personnel also will be intensified by the inclusion of non-U.S. personnel on U.S. space missions, starting with the Spacelab program.

The number of people on board a spacecraft also will increase with the Shuttle and SOC. The Space Shuttle can transport up to seven people into orbit, a more than two-fold increase over the Apollo missions. Moreover, Shuttle flights will include women for the first time in the U.S. space program. The addition of an orbiting Space Operations Center probably would further increase the number of people in space at any given time and would likely lengthen the duration of an orbital assignment beyond the currently envisioned maximum of thirty days on the Space Shuttle.

New factors will influence personnel selection and training, space facilities, designs, and the personnel procedures in orbit. Such factors will arise from a combination of: reduced social reinforcement for space service; the inclusion of women and professionals from a variety of disciplines and nations; and the probable lengthening of

Forty Pounds of Lead by Henry Casselli, watercolor, 23½" by 30½".



space mission durations. These changes in space mission profiles challenge behavioral and social scientists to be much more rigorous and develop improved powers of prediction. The consequences of poor social planning for space missions can be as severe as those of poor engineering. On the other hand, careful social planning can help prevent disasters resulting from human error and can augment the quantity and quality of a mission's results.

Behavioral, social, environmental, and industrial psychology can make valuable contributions to space missions. The challenge lies in applying the accumulated knowledge of these disciplines in new and more intense ways. The fundamental space program objectives include: (1) ensuring the physical safety of a space facility from human error or aberrant behavior, and (2) maximizing individual and group productivity. Psychology already has made a remarkable start in the direction of assuring more effective human performance in a variety of applied settings by precisely manipulating schedules of reinforcement and punishment.[4]

II. History of Orbital Human Factors

The United States and the Soviet Union have accumulated more than twenty years of experience with humans in space. By the end of 1982, over one hundred people had flown in space on missions ranging from fifteen minutes to 211 days. Given the untried nature of the activity, the accident rate has been remarkably low, with only three fatalities occurring in space itself during twenty years.[5]

U.S. manned space activities began with the suborbital flight of Alan Shepard in May 1961. Over the next two years, the Mercury program launched six men in tiny capsules into orbital or suborbital flights for periods from fifteen minutes to thirty-four hours. The origins, selection, and training of the Mercury astronauts, as well as the procedures used in orbit, are amply documented.[6]

The Mercury program was followed by the Gemini program (March 1965 to November 1966), which utilized very small two-man capsules. The ten Gemini missions ranged from four hours to fourteen days. The drama of the manned space program quickened in October 1968 with the first flight of Apollo, a program that had eleven missions ending in December 1972. The three-man capsules and associated lunar landing vehicles served as homes for a total of thirty-three astronauts who orbited the Earth or went to the Moon. The longest Apollo mission was twelve and one-half days. The program incorporated scientists into the astronaut corps for the first time; the selection, training, and on-board life of the Apollo astronauts have been covered in various accounts.[7]

In summary, the first ten years of the U.S. space program were marked by missions that launched into space no more than three individuals in any one vehicle. Astronauts were exclusively male and overwhelmingly drawn from the ranks of test pilots or scientists with pilot experience. The Mercury, Gemini, and Apollo vehicles provided extremely limited living space (5.9 cubic

meters, or 210 cubic feet, for Apollo), and the longest mission was only twelve and one-half days. However, the Skylab program (May 1973 to February 1974) offered larger living spaces and longer time in orbit, an environment more suitable for OHF analysis. In fact, Skylab was a Saturn upper stage rocket (14.6 meters by 6.7 meters, or 48 feet by 22 feet) that had been converted into a space workshop equipped for scientific research and manned by three-astronaut teams. The living area in the Apollo command module was multiplied by more than forty-five times in Skylab. Three teams served on board Skylab in missions that lasted from twenty-eight to eighty-four days.[8]

Through the Salyut 6 & 7 programs (1977-82), the Soviet Union added valuable information to an understanding of orbital human factors in long-duration missions (up to 211 days for two-man crews).[9]

III. Factors Affecting the Future of Orbital Human Factors

To structure an understanding of the future of orbital human factors, it is useful to establish two major categories: the near-term future (1980s and 1990s) and the long-term future (the 21st century). Each category includes unique space technological parameters, Earth-based social dynamics, and sponsoring institutions which combine in a kind of dialectic process to produce different varieties of OHF. Because key characteristics of future space operations will differ from early spaceflight, OHF experiences from the first twenty years of space activity will be of decreasing value.

A. The Near-Term Future (1980—1990s)

The near-term future can be discussed in terms of two technological subdivisions: (1) the Shuttle/Spacelab, the only manned U.S. space facility during the 1980s; and (2) the Space Operations Center (SOC), a permanently staffed orbiting space station. The SOC may be constructed during the 1990s.

The Shuttle/Spacelab missions will last no longer than thirty days, but as noted above will include women and non-U.S. nationals in American astronaut space programs for the first time. The program also will introduce the use of astronauts not trained to fly the space vehicle, i.e., the "payload specialists," who will be aboard Spacelab solely to conduct experiments and operate research equipment.

After the initial Shuttle/Spacelab missions, launches to space facilities gradually will become more frequent, engendering a substantial drop in media attention. The populace still will see space operations as exotic work, but not on par with the heroic status assigned to space exploration during the first twenty years of manned space activity. Space activities will become somewhat kindred to service in Antarctica, reducing the social reinforcement that often elicits extraordinary performance from individuals. However, the relatively short duration of the Shuttle/Spacelab missions (the majority well below thirty days) minimizes problems that tend to emerge on long-term missions, e.g., using and scheduling leisure time or coping with the build-up of latent personality conflicts among crew members.

As a discipline, psychology has analyzed extensively the role of interpersonal dynamics in any group setting. The group (or community) is subject to a wide variety of process variables at any given time. The characteristics of these variables are well documented in social psychology research; the literature also addresses the proper manipulation and control of group variables for the enhancement of the communities' good.[10]

The emergence in the 1990s of one or more permanently staffed orbiting facilities will reintroduce the potential for problems caused by extended human residence in space. Moreover, crew size probably will increase beyond the maximum of seven persons on any one Spacelab mission, augmenting the relevance of the questions that naturally arise when a group expands and becomes more heterogeneous. At this stage, the social questions pertinent to space operations mirror those of scientific and military bases and stations in hostile Earth regions, such as the Arctic and Antarctic.

In both the Shuttle/Spacelab and Space Operations Center programs, the primary sponsoring institution will be a U.S. government entity, NASA. Under U.S. government control, astronaut space missions are responsible to the full spectrum of public policy, and the handling of space-related social issues will be scrutinized closely by centers of policy formulation, such as Congress. Such reviews will tend to limit available options for dealing with OHF issues. For instance, policymakers will devote careful attention to public opinion in dealing with questions such as the health risks to humans exposed to cosmic rays.

B. The Long-Term Future (The 21st Century)

Human space activity in the 21st century will evolve into a diversified and increasingly complex experience. The expected technological improvements will provide capabilities for more robust manned space activity. Space facilities may well become more spacious, increasingly acquiring attributes of Earth-based facilities, including commodious living spaces and areas for leisure activities. Eventually, some of the Earth's flora and even fauna may be duplicated in space habitats, and in the very long term, facilities may begin to approximate orbiting towns more than isolated stations. In addition, technological advances may provide the means to establish living facilities on the Moon and possibly Mars. All these technological improvements would augur well for the opportunity for individuals to choose long assignments at space facilities.

Moreover, the U.S. government probably will be joined by non-governmental institutions in developing space operations and facilities. Among others, private companies, universities, and health and leisure institutions may sponsor or co-sponsor the establishment and maintenance of space facilities. However, active participation by non-governmental institutions will be determined by

the level and direction of economic benefits that accrue from space activities, such as the degree to which commercialization of space is advanced by using space-based energy and raw material resources and the value added during product processing in space.

The twenty-first century may see the evolution of company towns in space, comparable to the pattern in Dhahran, where the Aramco Corporation maintains 4,000 American employees at considerable cost in suburban-like towns in the midst of the Saudi Arabian desert. Other examples of industrial towns in an exotic environment include the Norwegian and Soviet coal mining settlements on Spitzbergen Island in the Arctic Ocean; these communities are operated at substantial cost, but the profits from their activities more than compensate for the level of effort necessary to sustain them.

In the very long term, individuals or communities may simply prefer space facilities to Earth as a permanent residence. At this point, the social configuration of human space activities may begin to simulate the experiences of earlier colonial times, when groups moved into physically hostile areas for other than purely economic reasons. An analogy can be found in the Mormon settlement of Utah in the late 1840s, an undertaking to secure freedom to practice religious beliefs unacceptable to the mainstream of society.

IV. Orbital Human Factors

A. The Near-Term Future (1980s and 1990s)

From a pragmatic point of view, the fundamental near-term objectives of OHF include insuring the physical safety of the space facility from human error or aberrant behavior and maximizing individual and group productivity. These objectives depend on three principal issues: the selection of space personnel; training; and in-orbit procedures.

(1) *Shuttle/Spacelab crew selection.* The crews for the Shuttle/Spacelab missions will include spacecraft operators and on-board researchers to monitor scientific equipment and experiments. The selection process for each group is different.

Personnel charged with operating the Shuttle include the commander, the pilot, and the mission specialist. The criteria for their selection are very similar to those applied to earlier astronauts—e.g., flight experience in high performance aircraft, ability to function effectively under stress, and general physical fitness; NASA itself selects spacecraft operators. Personnel responsible for on-board scientific equipment are known as payload specialists and may number up to four persons on any given Shuttle flight. Payload specialists are drawn from the scientific and technical community and chosen by a committee of scientists and researchers who represent the principal investigators on a particular mission. Each Spacelab mission will employ different technical and professional criteria to select payload specialists.

Both the pilots and payload specialists must pass basic medical and psychiatric evaluations; the psychiatric assessments seek to: (a) detect any overt or covert personality disorders; (b) assess the capacity to function as a productive member in assigned roles; and (c) identify individuals whose motivations and personalities make effective performance likely under the stresses of spaceflight.

The dynamics of human emotion and the interactive effects on individual motivation and productivity constituted a major area of interest for psychology scholars over the past two decades[11] and should be interrelated with spaceflight concerns.

(2) *Shuttle/Spacelab crew training.* Commander, pilot, and mission specialist training focuses on flying and operating the Shuttle under a wide variety of conditions. In many respects, such training is similar to that given to earlier astronauts and includes extensive use of simulators to develop appropriate responses to launch, flight, and landing contingencies. The training also develops precise and rapid intra-crew communications and control procedures and focuses attention on critical tasks during periods of psycho-physiological stress. One training objective is to build person-to-person and person-to-machine relationships that operate with maximum efficiency.

The payload specialists training takes place in two stages. The first stage trains candidates to operate the scientific equipment and experiments scheduled for a particular mission and usually is conducted at an industrial facility, government agency, or university. The second training phase familiarizes candidate payload specialists with basic flight skills, such as operating food and hygiene systems and developing competence in both ordinary and emergency procedures.

(3) *Shuttle/Spacelab procedures in orbit.* Because of the relatively short duration of the missions, a specifically scheduled set of crew procedures will be activated once the Shuttle/Spacelab is in orbit. Such procedures encompass three general concerns; the first is the work to be accomplished on the mission, which mainly includes the starting and maintenance of experiments and equipment (which in some cases requires around-the-clock attention). Correct pacing of mission work is an important consideration, because too slow a pace can reduce potential mission effectiveness, but too high a pace can produce insufficient attention to critical details and adversely affect crew morale. Behavioral factors that influence pacing of work and the modification of these factors have long concerned psychology scholars. Many authors have discussed the effects of learning and environmental manipulation of pacing.[12]

The second procedural concern focuses on crew health maintenance and biomedical monitoring, which involves a series of biomedical samplings and a vigorous exercise program each day to counteract the effects of zero gravity on the body, e.g., muscle atrophy and bone mineral loss. Personal sanitation is especially important, because certain microbes can increase dramatically in the confined, weightless environment of a space facility. Many tasks, such as the handling of laundry, are designed to insure maximum cleanliness.

The third procedural concern addresses simple living: eating, sleeping, and recreation. Shuttle meals are designed to be nutritious, tasty, and diverse because bland or monotonous diets can influence performance and morale. Careful attention is given to assuring regular, restful sleep for the crew. Optimal opportunities for recreation are provided within the limited resources of the Shuttle/Spacelab (e.g., cards, games, books, writing materials, and tape recorders to listen to music and note personal impressions). As a discipline, psychology studies in some detail the modification and analysis of human performance by manipulation of the individual's environment; these variables should be explored more closely in relation to spaceflight.

(4) *Permanently staffed facilities: crew selection.* The prospect of large crews, greater crew heterogeneity, and significantly longer assignments will exert new pressures on the astronaut selection process. The space program probably will need to select people with experience in construction, management, clerical work, and health services. In addition to the psychological criteria of the Shuttle/Spacelab program, the process will place increasing emphasis on candidates' adaptive competence, i.e., their capacity to adjust to new physical environments for extended periods of time while simultaneously maintaining effective performance and continuing psychological growth. Fortunately, humans are extremely adaptive organisms blessed with a relatively flexible psychological makeup. Nonetheless, during long space missions, astronauts must be kept psychologically as well as physically sound, and many psychology professionals should be interested in the clinical as well as the research implications of such behavior.[13] The assignments probably will require some ability to carry out repetitive and monotonous tasks, but also maintain the capacity to respond to sudden emergencies. Such missions also require the ability to adjust to the social environment of the space facility and to work effectively and harmoniously with co-workers. Mechanisms to evaluate adaptive competence must study the developmental history of candidates and assess future self-attitudes by using stress testing and peer evaluation.[14]

(5) *Permanently staffed facilities: crew training.* Training will address three basic concerns: adapting existing professional skills to space tasks, including familiarization with space-based equipment; learning the living procedures at the facility; and developing social adaptation skills. Social adaptation training addresses: (a) social sensitivity, i.e., understanding others, especially in circumstances that intermix education levels, social classes, cultures, and world views; (b) communication skills to articulate anxieties and frustrations and thus avoid escalating tensions and deviant behavior manifestations; and (c) group performance, including skills in leading, following, and facilitating group compromise. Such skill development represents an intrinsic part of social psychology and should be addressed by professional researchers.[15]

(6) *Permanently staffed facilities: procedures in orbit.* The operational procedures for a permanently staffed space facility of any size will have to account for a wide variety of human behaviors and needs. Moreover, operational procedures will become more complex as crews increase in size and heterogeneity and as individuals or groups of individuals are cycled in and out of the space facility. In contrast, entire Shuttle/Spacelab crews train and conduct space missions as a single unit. Only the Soviet space program has any experience in cycling crews (albeit very limited experience).

Operational procedures will have to address the often complex questions of authority, individual and group privacy, leisure activities, individual and group communications (both on board and to Earth), and individual or group psychological disorders. The use of hypnosis as a possible tool to reduce personal problems during spaceflight has been studied in recent years and may be considered for use in permanently staffed facilities.[16] The legal aspects of all planned procedures also will have to be carefully studied in advance of their establishment.

B. The Long-Term Future (The 21st Century)

During the 21st century, the psychological selection, training, and on-board procedures will gradually change in fundamental ways. The combination of improved space technologies and the diversification of sponsoring institutions will stimulate procedures much more similar to those used in mainstream society. Airflight provides a rough analogy; flying 950 kilometers per hour at 12,000 meters (600 miles per hour at 40,000 feet) once required very special selection, training, and operational procedures. Such flights are now available to nearly all members of society with no preparation beyond a two-minute introduction to the emergency life-support systems aboard an airliner.

Selection may devolve to simply preventing armed individuals from going into space. Training may be reduced to a simple orientation to basic safety procedures at the space facility. Operational procedures themselves probably will be aimed exclusively at safety and not necessarily at individual and group productivity.

In the very long run, as space settlements evolve into full-fledged communities in which individuals and families can live permanently, issues relevant to residence in space will merge into the ordinary questions of living on Earth.

Appendix Two materials provide insights from the experiences of two instructors.

Footnotes

1. The author is indebted to Dr. B. J. Bluth of California State University at Northridge for this observation and to Dr. Robert Ruskin of Georgetown University for some of the bibliographic references cited below.

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Sociology

Sociology and Space Development

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I. Overview of Sociology and Space Development

Sociology organizes knowledge to identify and analyze more of the hidden potential in human behavioral systems. The tests of sociological concepts are in behavior, i.e., does the concept work in real life? Systems of sociological concepts can be broken into three basic categories: social systems, or systems of ways of doing things; cultural systems, or systems of meaning (e.g., language, values, beliefs, ideas); and personality systems, or systems of need dispositions (internalized cultural and social systems). Using each of these systems, sociologists attempt to identify patterns of relationships between events and the systems, as well as among sets of systems and events. Sociologists thus examine the consequences of behaviors resulting from social, cultural, and personality systems and from interactions among those systems. Sociologists also seek ways to encourage desired consequences. Because sociology constitutes a way of organizing knowledge about human behavioral systems, the discipline applies to any type of human activity.

The study of human behavioral systems encompasses almost every aspect of space development in the near and far term. Presently, sociological issues include astronaut survival and safety and mission effectiveness. As the presence of humans in space expands in scope and duration, the quality of life in space as well as on Earth becomes pertinent.

Moreover, the unique environments of spacecraft and early space missions, the limited crew sizes, and the constrained Earth-space communication flows may enable sociologists to identify fundamental social processes to a degree not previously possible. In space, external influences are minimized, and information about behavior systems and their consequences is increased, but not beyond a manageable scope. Perhaps space development will be to the study of behavioral systems what the linear accelerator was to physics, enhancing the significance and development of human behavioral systems as a science.

With the move to space, humanity also has an unprecedented opportunity to maximize behavioral systems that significantly improve the quality of life. Never before has humanity sought to develop such an unbounded frontier with the aid of knowledge about arranging behavioral systems synergistically—trying to insure that what is good for the individual is good for the group and vice versa. Consequently, space development represents an unprecedented new start—a vast opportunity for fresh beginnings.

The overriding questions for behavioral systems studies become: What problems do we confront? What do we know? What don't we know? What do we want to accomplish? How do we accomplish our goals while at the same time preserving the integrity and interests of space crews?

In pursuing the answers to these questions, an important starting point is data from Soviet long-duration spaceflights, undersea expeditions, Antarctic research stations, submarine missions, and relevant simulations. Another important issue is the use of behavioral systems in the space program as a training tool versus use as a selection/elimination tool. For example, the Soviets have employed behavioral systems scientists to train cosmonauts to function at peak capacity under high stress. Such an approach is contrary to the current American practice of using behavioral testing as a criterion for including or excluding candidates for the space program. Soviet work in this area is thus unique and significant.

II. Technology-Based Instruction Modules

The sociological systems and issues discussed above can be applied to a variety of space technologies. Brief descriptions below review the sociological implications of Spacelab, the Space Shuttle, space applications and utilization, and permanent occupancy of near-Earth space.

A. Spacelab

With the advent of larger and more diverse crews living and working in space, human behavioral patterns become critical to mission success. Extremely complex schedules require careful orchestration of many variables for the smooth functioning of daily activities in orbit and on the ground.

(1) *Cultural systems.* Soviet experiences in the Salyut 6 space stations demonstrate that communication flows are a function of understanding many languages, notably the critical "spacecraft-ese" derived from the native language. However, fluency in that technical language, experimental languages, and Russian has not come easily to recent international crews. Furthermore, in an extreme emergency, rapid communication is essential, leaving little or no time for crew members to translate. Misunderstandings have arisen from linguistic variances, as well as from culturally-derived values and beliefs. Since Spacelab expects to host international crews, this becomes an important area for study. Even when crew members speak the same language, there is not always a common understanding of intent. For example, facial gestures also are an important source of meaning and means of communication. However, as fluids collect in the upper body during spaceflight, the face becomes somewhat "bloated," interfering with facial gesture communication. The person is saying one thing, but facial gestures do not correspond with the intended meaning, thus creating stress and misunderstanding, as the Soviets have noted. Communication of meanings over electronic media is also a unique realm and the only link to Earth for the crews. Misunderstandings can occur easily, even using two-way video links (let alone computers or radios). Because accurate and clear communication flow is essential, consideration of cultural systems becomes important. Additionally, the meaning of participation in the mission itself is also significant, especially as flights become more routine.

(2) *Social systems.* The coordination of systems for operating in space is fundamental to mission success. The core of most missions includes factors such as authority systems, decisionmaking responsibilities, scheduling flexibility, work flows, leisure and personal activities, and mission management systems. Work in the Spacelab Mission Development (SMD) III simulation illustrated difficulties that have occurred and the impact upon the mission.[1] Skylab experiences point to the importance of scheduling flexibility as well as interfacing between leisure and personal activities. Soviet experiences underline similar points. Moreover, the introduction of mission specialists, payload specialists, and scientists into Shuttle missions brings a new dimension to missions regarding expectations about how jobs are to be done as well as how decisions are to be made.

(3) *Personality systems.* The Soviets make significant efforts to ensure the personal compatibility of flight crews as well as to relieve psychological and interpersonal stress. The Soviets also have instituted a vigorous socio-psychological training program to facilitate cosmonaut self-confidence, independent judgment, and resistance to emotional stress in isolated and confined conditions. The Soviets also operate an in-flight socio-psychological program designed to identify and relieve increased stress levels. In spite of these precautions, the Soviets have encountered problems of hostility among members of the prime crew as well as between the crew and the ground control staff. Experiences with work crews in isolated research stations at the Antarctic and elsewhere document similar difficulties. However, to date the American space program has employed only limited psychological interviewing, testing, and screening to determine flight suitability of candidate astronauts. There have been some incidents on American spaceflights that indicate potential sources of interpersonal stress, and such problems assume increasing importance as mission crew personnel become more diversified and missions become longer. Furthermore, Spacelab's sexually mixed crews require study of need dispositions relative to sex role expectations, especially in high-stress or emergency conditions.

B. Space Shuttle

U.S. experience during the SMD III Management Study identified many mission development problem areas.

(1) *Cultural systems.* The study found that personnel often had different interpretations of mission directives and experiment parameters. Specifically, payload specialists have unique orientations and special backgrounds that must be interfaced with NASA management systems, lest the significance of space research and activities be seen from the perspective of academic or industrial career requirements, which can be inconsistent with NASA objectives.

(2) *Social systems.* The SMD III study demonstrated important problems of management coordination between space centers and payload or mission specialists. To date, NASA has shown extensive management expertise, but Shuttle missions will pose new management problems; for example, once numerous missions are planned simultaneously, with participation stretching around the world, management of behavioral systems will grow in complexity, requiring especially fine tuning.

C. Space Applications and Utilization

Remote sensing, information, and communication satellites can have a major impact on societies in the United States as well as in developing countries. Adequate application of human behavioral systems may prove a decisive factor in effective utilization of such technologies.

(1) *Cultural systems.* Many developing countries find new or alternative technologies to be mixed blessings. At times such technologies radically disrupt ongoing cultural systems, yet provide no new systems of meanings in their place. At other times, developing countries decide that current values and ways of thinking are inconsistent with newly-introduced technologies. Some people perceive—correctly or incorrectly—that the new technologies constitute a threat to old ways, and, consequently, such people resist the introduction of the technologies. A thorough understanding of the impacts of new technologies upon the cultural systems of advanced and developing nations is essential if the new technologies are to be integrated into societies and prove valuable.

(2) *Social systems.* Since new or alternative technologies often are developed in the West rather than evolved within developing countries, such technologies usually are introduced on top of social systems that are not

STS-4 at 00.52 sec. by Ren Wicks, oil, 48" by 36".

necessarily compatible with the new capabilities. Again, this type of progress can be disruptive to the population, the success of the technology, or both. People need to know how to use the technologies to their advantage, as well as develop the skills necessary to work in technology-based business and industry. Expectations about factors such as work habits, scheduling, and decisionmaking are integral to the success of new technologies and must be delicately interwoven with the ongoing social systems. The technologies themselves can be useful in pursuing this objective: for example, information and communication satellites are an important means of educating local populations, as the ATS 6 communications satellite demonstrated in India.[2] Satellite communications also can provide new channels for interaction among the business, industrial, and scientific communities, for example, by providing capabilities to conduct conferences, acquire timely market information, and exchange research and other data. In short, it is not sufficient to simply introduce new or alternative technologies; interfaces with local social and cultural systems must be forged if technologies are to be optimized.

(3) *Personality systems.* The need dispositions of many people in the developing world are different from those of people in the West; i.e., people in developing countries often have different desires and respond to different goals, all of which are an intrinsic part of their emotional make-up. Successful introduction of new or alternative technologies—such as remote sensing and communication or information satellites—must be assessed with this concept firmly in mind.

D. Permanent Occupancy of Near-Earth Space

Much of the research and analysis relevant to Spacelab applies to human occupancy of permanent space stations in low-Earth orbit and geosynchronous orbit. However, in permanent space stations, crew size will increase, as will time in orbit. Moreover, crews probably will be more mixed in professional background and training. Soviet experience in Salyut demonstrates that the longer the orbital stay, the more crucial human behavioral systems factors become. Furthermore, research conducted on workers in submarines, Antarctic research stations, undersea laboratories, pipeline crews in Alaska, and simulations confirms the potential disruptive power of interpersonal stress factors, which might ultimately pose a threat to mission safety and success. In addition to limiting factors noted for Spacelab, the environment and behavioral systems interfaces become important for longer-term space stations. For example, the flow of interpersonal relationships is influenced by the layout of the physical environment. Plans and areas for privacy, leisure, work activities, and personal maintenance all relate to the level of stress experienced by the crew. The nature of the physical layout itself is important: flexibility in fixtures and variety in the visual surroundings should be emphasized. Earth-to-space communications also assume increased importance in long-term occupation of space; people in remote stations may find that frequent interactions with Earth-bound friends, relatives, and associates are necessary to maintain their self-images during extended space duty.

Military uses of space, such as the introduction of space-based laser or particle beam weapons, may have a major impact on the way people think and relate to the world. If the threat of nuclear war is removed to space, what will the impact be? Furthermore, how would such a development affect international relationships, relations with developing countries, and other international links? Finally, crews manning space military units would be subject to pressures quite distinct from those affecting crews in civilian bases: For example, what measures would be required to preserve the crew's ability to function in such an environment?

E. Large-Scale Space Operations

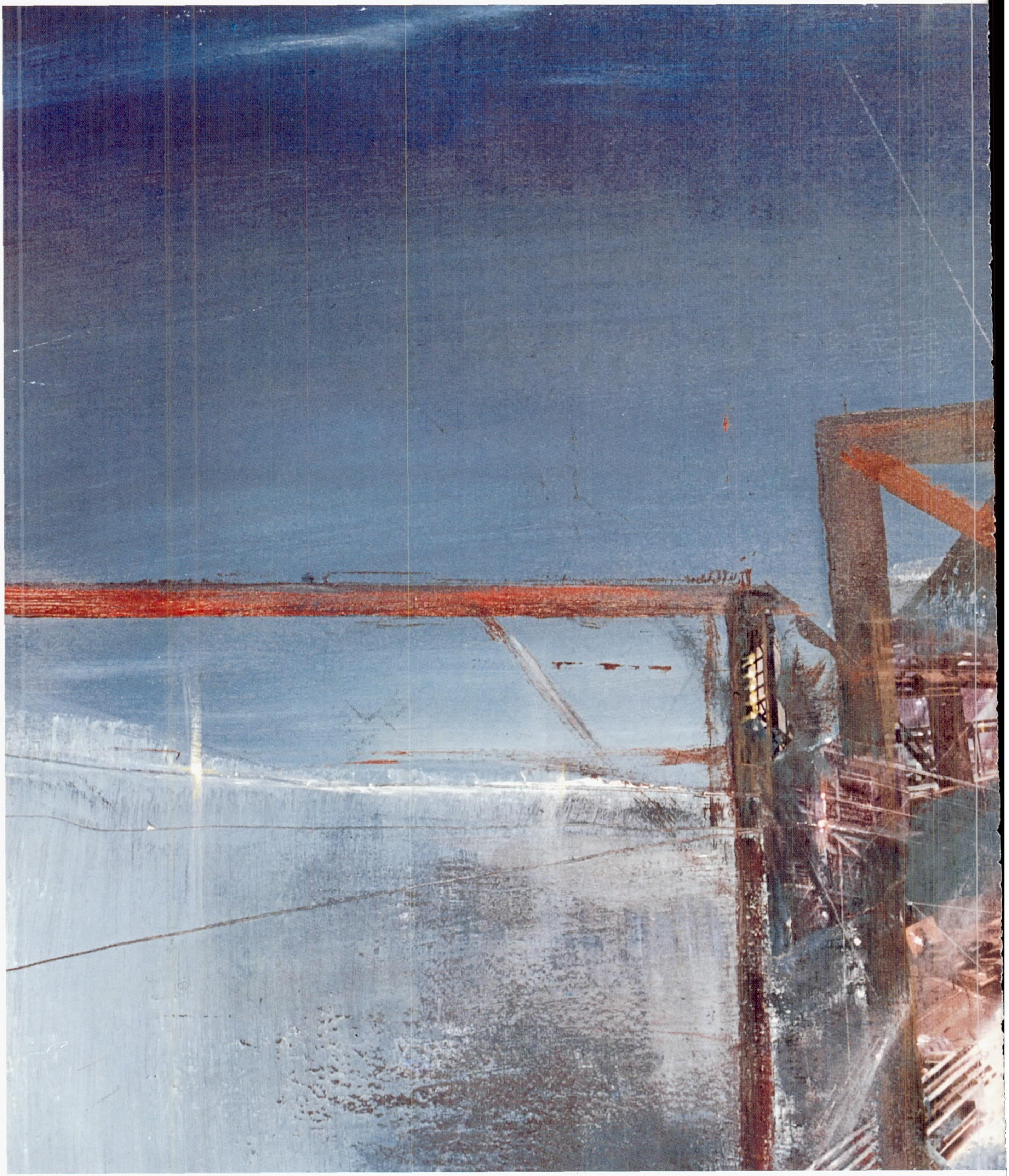
In the long term, projects such as expeditions to outer planets or permanent human settlement of the Moon pose many human behavioral systems issues. For example, when people moved from Europe to the New World and then on to the far West, the people and their cultures changed. Attitudes, values, and ways of living underwent significant alteration, and societies evolved with many members who could not be happy or comfortable in their old homes. The same phenomenon will affect those who opt to settle the planets. Moreover, such pioneers will develop immunological, cultural, and social divergences. In the past, however, pioneers sought new frontiers with new options, but brought little scientific knowledge about new ways of arranging behavioral systems. Consequently, new values and methods of operation evolved, but randomly. However, now it should be possible to apply behavioral systems approaches to the design of lunar and space communities, seeking to optimize the synergy between the individual and the group. Unlike specters of 1984, current research concludes that behavioral systems changes must be voluntary if they are to be successful. Behavioral systems cannot make someone self-confident, but they can afford opportunity for growth and for smooth-flowing patterns of interaction.

Appendix Two provides details on a course taught at California State University, Northridge.

Footnotes

1. The Spacelab Mission Development (SMD) III study employed a simulation in which Shuttle crews, ground control staff, and the principal investigators worked together on Spacelab experiments. A number of potential problems in coordination were detected.

2. The ATS 6 was an experimental communications satellite designed in part to bring educational television programming to parts of rural India.



Spirit of the Challenge by Carol Dick, mixed media, 18"by 32⅛".

C-2

ORIGINAL PAGE
COLOR PHOTOGRAPH

Flight of the Columbia by Jack Perlmutter, oil, 52½" by 40".

Chapter Three

Interdisciplinary Approaches

By its very nature, the social science study of space is an interdisciplinary endeavor, drawing on technical material, traditional humanities disciplines, and the variety of social science disciplines that evolved during the 19th and 20th centuries. Consequently, a single course or activity incorporating many social science disciplines requires careful structuring. Maintaining coherence is a genuine challenge in the face of the centrifugal forces inherent in any discussion of space topics.

Generally, instructors develop coherence by selecting a theme or analytical tool to serve as an "integrator." For example, future studies or intercollegiate debate (both discussed subsequently in this chapter) can act as such a theme (as well as serve as an interdisciplinary analytical tool). The Space Transportation System represents a technological integrator; in general, primary space technological systems are useful foundations for building an interdisciplinary approach to space into a single course or activity without succumbing to overly narrow issues. Additionally, a particular type of space activity, such as exploration or economic utilization of space, can provide course focus.

Any integrating theme must be carefully defined beforehand. Such care is vital because college students—usually approaching space for the first time in a systematic, academic way—tend to have broad-brush images and impressions of the space program, merging disparate space projects and technologies that should be clearly differentiated. For instance, a space-based, high-energy astronomical observatory and a communication satellite represent significantly different technologies and purposes despite the fact that both employ the space environment. Activities such as scientific exploration and economic utilization of space serve fundamentally different roles in society; however, these activities often are grouped together in the mind of a student new to space studies.

The utility of an integrating theme is illustrated in Appendix Three through a case study of a course taught at Georgetown University. Moreover, the genesis of the case study suggests that careful planning must precede a course which successfully interweaves complex technologies and a variety of social science disciplines.

This chapter also can provide insights useful to instructors whose courses have a predominant focus in one discipline but of necessity must incorporate interdisciplinary analyses for full understanding.

The analytical tools described by Joëls (future studies) and Snider (debate) encompass several interesting approaches to teaching interdisciplinary topics (exclusively or as a subsection of a course). Moreover, both future studies and debate tools can be adapted successfully for classroom use and can be used to focus discussions of the social science implications of Shuttle, Shuttle-related, and longer-term technology. Appendix Three provides more specific materials: several scenario topics, a brief reading list, and several course descriptions supplement the Joëls paper; instructors' observations and guidelines for in-class use of debate complement the Snider paper.

Future Studies

Future Studies: An Interdisciplinary Vehicle for Space Science Education

Kerry M. Joëls
Curator, Future Studies
National Air and Space Museum

I. The Study of the Future

The interdisciplinary study of space includes fields such as: the sciences, mathematics, and engineering of hardware; the management, politics, and economics of program governance; and the history, art, journalism, and sociology of the effort. Future studies also require a wide variety of interdisciplinary skills. Marrying the subject matter of space studies with the methods of future studies produces a wealth of interesting interdisciplinary educational experiences.

Future studies, as the term evolved in the curriculum, does not deal exclusively with attempts to predict the future. Future studies can help to define the current status of society—e.g., technologically, socially, esthetically. This "world view" then can be compared with other potential "world views" through a series of intellectual filters.

Of course, there is a predictive element to future studies. Trend analysis, surveys, statistical analysis, operational research, and systems research are just a few of the techniques available to the futurist. In fact, all three major divisions of research—experimental, descriptive, and historical—are used in the process called "futuring."

At first blush, one might assume that a futurist is primarily concerned with scientific and technical trends and their societal impacts. Futurist literature often creates this impression. But, as the field has matured, futurists have explored ethical, sociological, esthetic, and other considerations. The interdisciplinary aspect of space studies and the interdisciplinary nature of future studies techniques provide numerous dynamic combinations from which one can create stimulating sets of classroom experiences.

Studying the future creates another by-product: an awareness, or even an inertia, which can change the future or allow a better acclimation to the future.

Techniques used in the futuring process vary widely, but often include: (1) Delphi surveys, questionnaires, and polls that use individuals with specialized or generalized knowledge and attempt to reach a consensus on future options; (2) statistically-based methods such as extrapolation, probability, variance, regression, or correlation techniques; (3) analogies with existing systems or theses and scenarios developed to describe policy options (for example, see McDougall on historical analogy); and (4) role playing, simulation games, conflict resolution, mediation, negotiation, and other group dynamics techniques for planning and projecting the future.

II. Tools for the Futuring Process

A. Delphi Surveys, Questionnaires, and Polls

Perhaps the simplest techniques for futuring exploit expert opinion. Recently I had a lecture on the future of humankind from a New York cabbie. His conclusions were reasonable, and his sources—e.g., television, the *New York Daily News, Time* magazine—were unimpeachable, if unimpressive. A poll of such "street philosophers" probably would reveal a great deal about how the thinking "ordinary working person" feels about the future. However, to verify such conclusions one would need statistics on New York cabbies, including: age, education level, outside interests, ethnic background, and income level.

A substantially easier and more reliable means of building a data base is to poll or survey a more intellectually homogeneous group about specific aspects of the future. The Delphi technique was developed for just that purpose. Delphi surveys employ several rounds of questionnaires, and participant feedback from preceding rounds is used to refine questions for successive rounds. The entire process is supervised by referees, who also generate the questionnaires. The questionnaires generally focus on forced-choice questions, for example: The space program would receive more funding if a major mineral deposit was discovered on the Moon. a) Strongly Agree, b) Agree, c) Neutral (no opinion), d) Disagree, e) Strongly Disagree.

Florida Coast—Fire Pillar by James L. Cunningham, acrylic, 24½" by 24½".

The feedback provided between rounds is distributed to participants, who can compare their responses to the aggregate opinions of the group. Participant comments and questions also are incorporated into the next round of questionnaires. Such studies usually tend to develop a consensus. Moreover, Delphi surveys can be conducted by mail, creating a sample of many individuals in diverse locations.

One-shot polls and questionnaires also can be of some value in gathering data or refining questions. Panel discussions incorporate group dynamics and represent another device for examining policy options and defining opinion and dissent on future-related topics.

B. Statistical Tools

Statistical methods of prediction have been and continue to be widely used in future studies. Extrapolation curves "picture" projected changes or reflect the effects of outside disturbances on previous trends or forecasts. For example, a study might assess telecommunications devices which might dominate the weakest sectors of society and consequent behavioral or social changes. The study might concentrate on one particular product, e.g., home satellite antennas. Since the television viewing habits of families who own the device are known to be different from those of families who do not own an antenna, could the study predict the effect of widespread use? A simple linear extrapolation may not be relevant, because there obviously is some limit to the number of antennas that could be sold. Price breakthroughs, variations in economic conditions, or the development of an alternative technology (e.g., the read/write video disc) could all dramatically affect any projected trend curve. The linear, exponential, or "S" curves that might be generated all tell different stories and suggest different societal effects.

Correlation, another analytical tool, can investigate both possible relationships among subjects with varying characteristics—e.g., age, salary level, education level—and other discrete or continuous variables. Such correlations can develop useful inferences on future-related topics. For example, if there was a high correlation between salary level and the likelihood of purchasing a home satellite receiver, researchers might be able to identify a specific group whose behavior might ultimately change as a result of such a purchase.

C. Analogies and Scenarios

Less mathematically-based future studies activities often use analogies and scenario development. Many historical and natural precedents can form the basis of meaningful forecasts. Rates of diffusion, population increases or decreases, and other factors often constitute natural yardsticks for measuring the accuracy of predictions or observations. Historical analogy facilitates research into parallel or analogous situations. For example, a stimulating and useful comparison can be made between the rise and fall of Ming dynasty naval exploration and contemporary space exploration.

Scenario development hypothesizes a variety of possible social, economic, and political developments and discusses the implications of such developments individually and in combination. A scenario also is a framework for structuring forecasts. The scenario can depict a detailed future (with extensive discussion about the ramifications of significant factors) or make a simple statement of condition (allowing the identification of relevant variables and the discussion of policy options). An illustrative list of possible scenarios is included in Appendix Three.

D. Role Playing and Simulation Games

Futurist studies also have adapted several group dynamics techniques in widespread use in the social sciences. Role playing permits firsthand student participation in the decisionmaking process and incorporates a great many affective (emotional) factors surrounding specific issues. In role playing, students may individually or collectively form evaluation boards, conduct hearings, or assume the roles of competing mission scientists, spacecraft designers, civilian review boards, and other "stakeholders." Congressional testimony and technical documents provide a wealth of background information—and periodicals (e.g., *Aviation Week and Space Technology*), newspapers (e.g., *The New York Times, The Washington Post,* the *Wall Street Journal,* and the *Christian Science Monitor*), and news magazines and commentaries often publish materials on contemporary space science issues. The research necessary to prepare for an effective role-playing exercise hones skills which can be applied to all academic activity.

Conflict resolution and negotiation skills can be subcomponents of role-playing activities. Launch schedule allocation, mission priorities, research and development funding, and other specific problems can be negotiated and resolved in the classroom setting. Occasionally, even seemingly irreconcilable positions (e.g., space as a boondoggle versus a salvation) can serve as fascinating vehicles for lessons in comparative values. Such lessons often translate to post-graduation industrial and professional settings as well.

Simulation gaming requires more extensive preparation but also transfers learning out of the textbook and into the experiential realm. A simulation game can be win or no-win and can utilize all the foregoing techniques.

Hypothetical or actual conflicts involving groups, nations, or individuals provide a framework for the evolution and testing of strategies appropriate to the particular goal of the chosen game. Games should be constructed to avoid the cheap or quick victory. Therefore, game development often proceeds experimentally, until the bugs can be worked out. Of course, playing such games can consume a great deal of time and consequently might be considered a "laboratory" experience.

Suggested game topics include: limited or limitless growth, space funding, star wars—the military in space,

U.N. conference on communications resources, energy—the space option, and designing the manned Mars mission. All of these topics suggest obvious multivariable problems and opportunities for competing philosophical or technical objectives. Some games are designed specifically as no-win games which allow a variety of conclusions; sometimes the process of the game is more important than the outcome. Such factors should be clearly stated in the game instructions.

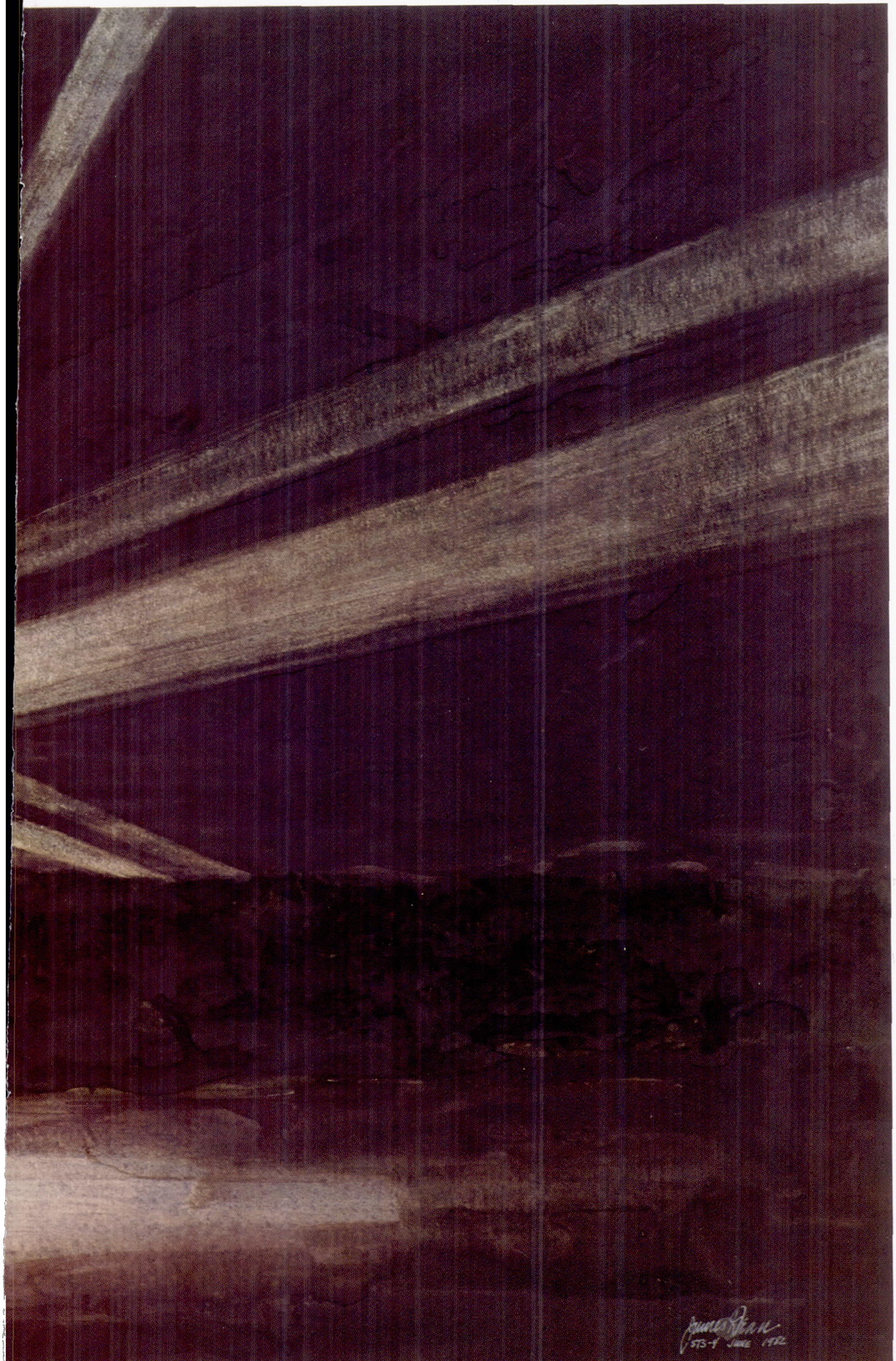
The students may wish to design their own scenarios for role-playing situations or games. Elements of gaming (objectives, methodologies, strategies, chance) can all be integrated into the game structure. Success in the game can be measured in terms of accumulation of position, wealth, resources, positive decisions, or success at compromise, cooperation, or adaptability.

A selection of space science future scenarios appears in Appendix Three to serve as an idea bank for the various techniques discussed. The scenarios can be used as a basis for: developing analogies; suggesting trend analyses; undertaking policy analyses; creating questionnaires or Delphi surveys; or even conducting interviews with faculty "experts" and refining the scenarios themselves. The sample scenarios also provide topics for role-playing and simulation games.

Clearly, the future is not predictable. No amount of statistical evidence renders any system totally knowable, and natural systems have both quantum and macro uncertainties. However, a choice of futures is more likely when there is an adaptation to change. Moreover, perceptions of the future are as powerful as events themselves. Cultural overlays to objective events and ethical and philosophical factors are all part of perceiving and thereby interpreting the future. The most important aspect of the Club of Rome report on limits to growth, for example, may be the futures we avoid as a result of the analysis. The dire predictions of shortages, overpopulation, and ecological disasters may be avoided through timely recognition of dangers and modification of group and individual behavior. In this vein, societal momentum or inertia can be affected by the futurist. Since all predictive techniques influence the perception of reality, the futurist can play an important role in corporate, governmental, technological, and academic activity.

Appendix Three materials also include a brief reading list and several course syllabi that reflect the above methods.

Night Watch by James Dean, watercolor, 19½" by 29½".


STS-4 JUNE 1982

Shuttle Rollout from VAB by Nicholas Solovioff, sepia wash, 29″ by 21″.

Debate Analyses

Space Utilization as a Subject of Academic Debates

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Assistant Professor
University of Vermont

I. Academic Debate as Interdisciplinary Education

Today, on college and university campuses and in high schools all across America, thousands upon thousands of students engage in an organized forum for discussing important issues in our society and educating participants about decisionmaking processes. This forum is interscholastic and intercollegiate academic debate. Large numbers of students compete as representatives of a broad spectrum of high schools, colleges, and universities. Moreover, debate can be used very successfully as a tool in classroom discussions of important concepts and issues; basic guidelines for using debate as an in-class educational tool are detailed in Appendix Three.

Competitive and in-class debates serve several important objectives. First, debates usually focus on policy issues with important societal implications. Debates thus offer instructors a unique opportunity to relate often abstract classroom theories to "real world" issues in an area interesting to most students. For example, policy debates centering on space-related topics can be employed in economics, foreign affairs, political science, history, and almost any other social science discipline (although in some fields debates on value topics rather than policy topics are more appropriate). Second, debates provide a significant educational experience. Obviously, students learn about the processes of "debate" and "decisionmaking" during the activity, but, additionally, debaters consistently utilize skills such as: public speaking, logic, persuasion, organization, research, composition, and other subtle tools relevant to such a complex act. Third, debate encompasses an element of play and competition that attracts and stimulates students, promoting the educational process. Debates that focus on space policy issues frequently appeal to students because of factors such as: student interest and stakes in the future, both as individuals and members of a society with long-term concerns; student fascination with new adventures and challenges; student concern over potential limits to growth and the need for new frontiers and additional resources; and student involvement with technology (e.g., electronic video games, computers, videotape decks), which often leads students to consider both the potential and the disadvantages of high-technology solutions to social problems, which often constitute the partial or virtually total product of technological progress.

II. Points of Stasis in Space Utilization Debates

In debates focusing on space utilization, certain issues seem to come up over and over again. Such issues may be thought of as points of "stasis." From the perspective of Gass, there exist certain points of stasis, or "centers of controversy, which inhere in all policy disputes."[1] Thus, policy questions in and of themselves lead to certain points of stasis. Some of the points of stasis in debates encompassing space utilization are reviewed below. When relevant, such points of stasis can be applied during in-class debates.

A. Resource Limitations

Several issues seem relevant here. First, affirmative teams are prone to argue that space utilization represents a viable answer to growing resource shortages. Second, negative teams often respond that the initial cost of such endeavors is too high. Third, negative teams argue in some situations that any expensive affirmative proposal for non-space-related programs will be funded at the expense of continued space utilization programs. Each topic is discussed briefly below.

First, debaters see space utilization as an answer to resource limitations. Human history has been a story of expansion: populations, wealth, occupied land, and the ability to control nature have all increased. However, many concerned scholars contend that unlimited growth on Earth cannot proceed much longer without a world collapse, i.e., accelerating resource depletion in the face of vastly larger populations. Perhaps the seminal document in this field is the Club of Rome 1972 publication, *The Limits to Growth,* prepared by a study group of scientists and industrialists concerned with the future. The authors sought to assemble, in mathematical form, all known data about population, pollution,

food supplies, industrial needs, and the synergistic interactions among such elements. They then constructed an elaborate computer model and concluded that, if current trends continued, world civilization would collapse before the year 2100. The authors noted that the only way to avoid such a disaster would be adopting a policy of limited growth.[2] Although the study has been attacked for methodological shortcomings, this research nevertheless provided a powerful impetus for debaters, encouraging many debate teams to look toward the future—emphasizing the ecological impacts of growth, the uses of greater wealth, and the distribution of existing wealth into a limits-to-growth model.

Affirmative teams advocate space utilization as a way out of this trap, arguing that we are at an important turning point and must take action to escape a closed-system Earth. R. Buckminster Fuller, a common source among debaters, has noted that "we are in an historically critical state of humans aboard spaceship Earth. I think we have been given adequate resources to absorb our many trial and error explanations for knowledge. We have been allowed to make a great mess of things—until now."[3] Specifically, a number of affirmative teams propose space development along the lines suggested by Gerard K. O'Neill.[4] Such development would use current space technology to build space habitations. For example, some teams have proposed that space developers might build a small station on the Moon, where a mass driver (a device to use solar energy to electromagnetically propel pieces of lunar material to a spot in space between the Earth and the Moon) would deliver resources to a small space manufacturing center. Utilizing solar energy, the manufacturing center would process the raw materials into usable form and create larger habitations, exploiting the weightlessness of space. Workers also could begin building solar power stations to supply energy to work units in space and to the Earth. Eventually, lunar or asteroidal material might be processed in space for use on Earth. Thus, space development could provide unlimited energy at a low cost, as well as unlimited raw materials. In the long run, habitations might evolve into large, self-enclosed worlds housing hundreds of thousands, or even millions, of persons. Thus, affirmative teams have been directly addressing this point of stasis—limited potential for terrestrial growth—by proposing long-term space utilization.

Second, as economic considerations are used by the affirmative to justify dramatic space utilization proposals, so cost issues are a significant consideration in negative teams' responses to these proposals. The cost could be enormous, and negatives charge that proponents of such proposals have drastically underestimated the required investments. As the *Washington Star* observed in an editorial, ". . . most scientists do concede that O'Neill's ideas are technologically sound, though not all of them feel that they are economically feasible."[5] In fact, some estimates suggest that such a program will cost thousands of billions of dollars (for example, those of Garrett Hardin[6]). Negative teams sometimes argue that major breakthroughs in land-based fusion electricity generation could easily destroy the economic viability of space-based solar energy systems.[7] Thus, negative teams call into question the economic costs and practicality of long-term space utilization proposals.

Third, against many expensive affirmative proposals for non-space programs, negative teams argue that needed funds would come at the expense of the space program, which is far more cost-beneficial. For example, one negative team (from the University of Louisville) contended that the deployment of an anti-ballistic missile system (advocated by the affirmative, Augustana College of Illinois) would prompt the Administration to cut NASA's budget significantly, thus depriving the United States of the many possible benefits of short-term and long-term space exploration and utilization. The presumption here is that the Administration will allow neither an increase in total federal spending nor an increase in the budget deficit; consequently, as the affirmative advocates more military systems, funds must be freed from other parts of the budget, in this case mostly from NASA, which negative teams portray as a program high on the list for future cuts. In this way, any expensive program may be transformed into an argument over space utilization. Thus, the advisability of future space programs has become a point of stasis itself within academic debate.

B. Security Concerns

Almost everyone can agree that national security is an important issue, but debaters are concerned with issues of "terrestrial security" as well. Three types of security issues have emerged in debates where space utilization is an issue.

The first concern addresses the Soviet Union's intentions in space. Debaters are anxious to take competitive advantage of the evolving views of many citizens about the Soviet Union's space activities, popularly perceived as a security threat. Thus, debaters introduce arguments based on the potential of the immense Soviet space program to literally swallow the U.S. space effort. To avoid a "Solar System Red," debate teams propose vast new space programs to counter the Soviet challenge in space. Such teams argue that national security demands protection from attacks originating both on the Earth *and* in space.

Oddly enough, the second space utilization security issue takes off in the opposite direction. For example, in the final round of the Georgetown University High School Institute Debate Tournament,[8] a team contended that the Soviet posture is largely reactionary, and a surge of American space development most likely would precipitate an arms race in space. This scenario assumes that once we have significant assets and interests in space, we cannot avoid the need to protect such assets. Thus, space development guarantees an expansion of Soviet-American competition into space, with deadly consequences. We might find, as one critic of space development has suggested, an

Florida Homecoming, by Kent R. Sullivan, oil, 32″ by 28″.

updated version of the "lifestyles of centuries past, when raids of the Normans, Berbers, and other seafaring peoples depopulated Earth's coastlines—except that this time the weaponry would be a great deal more destructive."[9] The implications of this position seem rather obvious and certainly represent an alternative security scenario which might be useful against an affirmative team advocating massive expansion of space utilization programs.

The third security concern analyzes the position of the United States vis-a-vis the underdeveloped nations, commonly referred to as the Third World. A recognition of space development as an important world issue probably accompanies a view of the world as an interdependent system. As such, it is hard to imagine disaster overtaking the Third World without a similar emergency being visited on the other two centers of world power—the Western nations and the U.S., and the Eastern nations and the Soviet Union. Debaters often utilize the tremendous suffering and hardship in the Third World to generate a significant impact for certain arguments. It certainly is not a farfetched hypothesis that actions in the developed nations exert an important influence over the total human suffering in the Third World. Debaters usually apply these relationships to space utilization by examining the need to improve the life of Third World peoples before they use force to demand their share of the world's wealth. As one Third World spokesperson, Abdelkader Chanderli, has stated:

> . . . we are rapidly moving toward a huge explosion because of the gap between the rich and the poor. Sooner or later people with bare hands will be more powerful than all the damned sophisticated weapons together. You cannot destroy one billion people. You have to live with them or die.[10]

Many debaters posit the expansion of space utilization as an answer to this crisis. These debaters argue that solar power satellites could provide unlimited energy to the Third World, that raw materials processed in space could supply the basic ingredients for a new world order, and that improved satellite technologies would both revolutionize educational opportunities and provide the knowledge base necessary for leapfrogging technological progress in the Third World. Such teams argue that infusions of wealth from space are the only way to avoid the violent perils of world poverty.

C. Technology Spinoffs

To date, American space utilization undeniably has produced considerable technological benefits. Techniques and technologies central to the fields of electronics, computers, medicine, and physics are products of the space program. Many studies reported in the popular literature document such benefits, and debaters naturally have taken advantage of such evidence. Figures demonstrating the space program's positive cost-benefit ratio, attributable in large measure to technological spinoffs, certainly help debaters to justify increased expenditures for space programs.

However, the issues of technological expansion which are so closely linked with space utilization are not all positive. Debaters also raise the specter of space as a "dehumanizing" environment because of its heavy emphasis on technology. For example, George Wald has declared, "What has already gone much too far on Earth in technologizing all aspects of life—nutrition, motion, medicine, birth and death, and everything in between—will find its complete consummation in space."[11] While technology may provide interesting creature comforts, debaters often seriously question the concomitant impact on human relations and the richness of people's lives.

Finally, an interesting aspect of the various points of stasis in space utilization discussions is that many of these points come from entirely opposite directions. For example, the points of stasis surrounding technological progress are very bipolar—one argument emphasizes that more technology is a positive force, while the other contends that more technology is disadvantageous. Although such arguments are not necessarily common in the public policy arena, they are certainly typical issues in debate rounds. Such debate arguments are unique because competitive debate structurally demands a high degree of bipolarity. The realities of competition actively encourage teams to establish positions in direct opposition to those of the other team and then to defend such positions as fully as possible. As a participant in and a coach of academic debate for seventeen years, I am familiar with the intellectual struggle one often confronts while building a negative strategy against an affirmative case that—objectively—is probably a good idea. For example, when an affirmative team argues that the U.S. should feed starving people overseas, a negative is hard pressed to prove that such suffering people "don't exist" or "shouldn't live." Yet, negatives must argue in a consistent and radically different way from the affirmative in order to convince judges that "the U.S. shouldn't feed hungry people"—or, at least, shouldn't use the affirmative's proposed approach. Negative teams often resort to a complex position based on limited world carrying capacity, the impacts of food on population growth, and the potential of alternative food distribution systems. Much the same strategy must be used against cases advocating large increases in space utilization programs. To counter what may seem like a good idea, negative teams must employ any reasonably feasible arguments of a bipolar nature.

III. Space Utilization on Specific Debate Topics

The national bodies controlling collegiate and high school academic debate perform one major function, selecting a topic which is debated by all schools for an entire year. Some of these topics have been more closely linked to space utilization than others. For example, under the 1978-79 college topic on employment opportunities for all citizens, many very successful teams advocated space

utilization as an answer to America's employment problems, arguing both that technological spinoffs would create a large number of jobs and that the space program itself would require many highly skilled workers who were in oversupply. Moreover, since long-term economic growth (and job creation) is linked to energy supplies and resources, this approach also was applied to increasing long-term job opportunities.

Appendix Three materials also include a brief summary of the teaching and research experience of two intercollegiate debate coaches.

Footnotes

1. Robert Gass. "The Stock Issues Perspective: A Reappraisal." 1980, p. 2.

2. Adrian Berry. *The Next Ten Thousand Years.* N.Y.: Saturday Review Press, 1974, p. 13.

3. R. Buckminster Fuller. "Technology and the Human Environment." In: Toffler. *The Futurists.* N.Y.: Random House, 1972. See footnote 4, pp. 304-5.

4. Gerard K. O'Neill. *The High Frontier.* N.Y.: William Morrow and Co., 1977.

5. Editorial. *The Washington Star.* November 3, 1977, p. A14.

6. Garrett Hardin. In: *Space Colonies.* N.Y.: Penguin, 1977, p. 55.

7. See footnote 6.

8. A text of this debate is included in: James J. Unger. *Second Thoughts.* Skokie, IL: National Textbook Co. 1978.

9. Paul Csonka. "Space Colonies: Blueprint for Disaster." *The Futurist.* October 1977, p. 288.

10. Abdelkader Chanderli. *On Growth Two.* 1975, p. 23.

11. George Wald. In: *Space Colonies.* See footnote 6, p. 44.

The Cape Winds by Attila Hejja, oil, 30″ by 60″.


NASA
United States

The Landing —Columbia 3 by Jack Perlmutter, oil, 44″ by 46″.

Appendix One

Space Technologies—Resources

NASA provides a variety of education services for teachers, students, schools, and communities. A free pamphlet describing these services is available from: William D. Nixon, Code LFC-9, NASA Headquarters, Washington, D.C. 20546.

NASA also offers a variety of films, film strips, and audiotapes that can be borrowed by educational, civil, industrial, professional, youth, and similar groups. A pamphlet describing audio/visual materials is available from: NASA, Code FVM, Washington, D.C. 20546.

Appendix Two

Resources for Individual Disciplines

Economics

NASA's Influence on Industry and NASA's Economic Impact on Science (A Case Study of Astronomy)

Jerome Schnee
Business Administration Department
Rutgers University

I. NASA's Influence on Industry

As a result of NASA's multi-billion-dollar budgets during the 1960s, the agency became an important customer for several U.S. aerospace industries. Total sales of aerospace products increased from $16.4 billion in 1961 to $22.6 billion in 1967. Among the three major components of industry demand—Department of Defense (DoD), NASA and the Atomic Energy Commission (AEC), and the commercial purchases—a significant shift in relative importance occurred during this period. The combined NASA and AEC share of total industry demand rose from 4 percent to 19 percent, commercial purchases rose from 11 percent to 18 percent, and DoD dropped from 85 percent to 63 percent.[1]

The importance of NASA as a source of industry demand increased each year from 1960 to 1965. From 1963 to 1965 the rising demand from NASA programs served to offset decreasing defense purchases within the industry. The major impact of increased NASA purchases in the aerospace industry during this period was a shift of employment away from aircraft production and into missiles and space production.

In 1966 the relative importance of NASA purchases began to decline because of large increases in defense and commercial purchases. Demand for military aircraft rose as a result of the United States commitment in Vietnam; there was also a rise in the commercial demand for transports. As a result, the aerospace employment shift of 1960-65 was reversed. By 1966 employment in missiles and space had declined by about 70,000 workers from its peak level of 578,000 in 1963.

The space program played an integral role in the development of the international communications industry. The first satellite communication system, Intelsat-I, became operational in 1965 after a fifteen-year national R&D effort to develop commercial communications satellites. During this development period, NASA (with the assistance of various military agencies, AT&T, Space Technology Laboratories, and Hughes Aircraft) carried out several additional innovations to advance satellite communication technology.[2]

Because of their greater channel capacity, Intelsat-I and subsequent satellites spurred a major expansion in the volume of international communications. Between 1966 and 1970, the volume of international communications (excluding telephone) increased by 55 percent; this increase represented the highest rate of growth for any five-year period since 1961. By 1971 Comsat, which had been created to manage the U.S. commercial communications satellite system, had invested almost $200 million in equipment and facilities; between 1965 and 1970 Comsat's revenue grew from just over $2 million to nearly $70 million.[3]

The new technology which industry acquired from NASA had a significant effect on the industry's cost structure. The annual cost of a satellite communication circuit was $25,000 when Intelsat-I was launched in 1965; the cost had dropped to $719 when Intelsat-IV was launched in 1971. The annual cost of a circuit dropped to $30 by 1976 when Intelsat-V was placed in orbit. The cost of Earth stations also declined substantially; whereas Earth station costs ranged between $6 million to $12 million in 1968, the range had been reduced and narrowed to $2 million to $4.5 million by 1971.[4]

The commercial results of these technological advances are reflected in the history of transatlantic telephone charges. For example, the monthly rates for a leased telephone circuit between New York and Paris remained unchanged for a number of years, but in 1966, immediately after the first communications satellite went into operation, monthly charges dropped sharply and have continued to drop since that time. The $4,625 monthly charge in 1971 was less than one-half the monthly rate for 1965.[5]

In addition to generating specific technological gains for industry, NASA also sought to promote general technological progress. In 1962, NASA established a Technology Utilization Program to promote the transfer and application of its technology to other organizations. When the Technology Utilization Program was created, it was widely believed that the technical by-products of the space program, or "space spinoffs," would be both large in number and commercially significant. The concept of space spinoffs assumed that a specific, discrete innovation in the space program would be identified as relevant to a need outside the program and then would be adapted and applied commercially.[6]

Evaluations of the Technology Utilization Program failed to uncover a significant number of technology by-products. It became apparent that the term "spinoff" was misleading, because it implied that space contributions were directly and readily identifiable when, in fact, they were not.[7] As a result of such findings, NASA switched the focus of the Technology Utilization Program from generating space spinoffs to developing improved methods of technology transfer.

A subsequent Denver Research Institute (DRI) study concluded that the principal technological impact of the U.S. space program has been acceleration of technical advances. DRI estimated that a major share (78 percent) of NASA's technical contributions were advances that would have eventually occurred even in the absence of the space program; NASA's role was to accelerate development.[8]

What is the economic value of NASA's technical "acceleration effect?" Drawing on four case studies (gas turbines, cryogenic multilayer insulation, computer simulation, and integrated circuits), Mathematica, Inc. concluded that the economic benefits that result from NASA's acceleration of technology are very large. The value of a speedup in technology in those four fields was estimated to be between $2.3 billion and $7.6 billion in 1974 dollars. Mathematica's "most probable" estimate is that the four case studies alone produced savings equal to 6 percent of all NASA R&D expenditures since 1958 (on a discounted value basis).[9]

II. NASA's Economic Impact on Science: A Case Study of Astronomy

The U.S. space program produced a dramatic and permanent transformation of astronomy.[10] In order to fully appreciate NASA's impact on astronomy, it is useful to characterize the science as it existed during the pre-NASA years. Prior to the 1950s and 1960s, astronomy was a small science growing at a modest pace. The number of astronomers was in the hundreds, with an average annual growth rate between 4 percent and 5 percent. The science remained small during the pre-1950 period, because research funds and observational facilities were both limited. The three or four institutions that controlled the big telescopes dominated the science in every way. Astronomers concentrated on observation rather than the kind of experimental design work which typified physics and other scientific disciplines.

The limited funds and observational facilities discouraged astronomers from considering improvements in instruments, and, as a result, astronomy was slow in adapting technology developed elsewhere. Thus, the major pre-space exploration advance—radio astronomy—originated with university electrical engineers and physicists, not astronomers. Radio astronomy flourished during the 1950s, as scientists familiar with instrumentation and engineering moved into the field. The development of this new branch of astronomy was dependent, in large measure, on the willingness of the Department of Defense to fund expensive radio astronomy facilities. Total astronomical funding began to increase substantially during the early and middle 1950s because of the support of several federal agencies.

At the outset of the space program, astronomers were not enthusiastic about the opportunities for space exploration. While there were benefits to be gained from space observation, much of the scientific community was distressed about NASA's substantial commitment to engineering and hardware production. Despite the efforts of NASA's senior management to enlist the aid and support of astronomers, the astronomical community continued to give highest priority to ground-based instruments and research through the mid-1960s. It was not until the Greenstein Report of 1972 that astronomers acknowledged the unique role that space observations can play in advancing the science.

NASA's direct scientific contribution to astronomy may be grouped into three categories: the resurrection of old astronomical fields (celestial mechanics and geodesy), the creation of new astronomical fields (lunar and planetary studies), and the synergistic effect on optical and radio astronomy. As important as NASA's direct scientific contributions have been, the influence of the space program on the organization and structure of astronomy may equal or surpass direct support. There has been a substantial increase in the size of the profession during the space era. Over the 1960-70 decade the number of astronomers tripled to approximately 2,500, with an annual growth rate of 15 percent over the last part of the 1960s. Financial support from NASA, the National Science Foundation, and the Department of Defense produced an equivalent upsurge in the number of astronomy doctorates.

The combined influence of large funding increases, sharp rises in manpower, and the demands of space experimentation forced astronomy to take on many of the characteristics of big science. Increasingly, astronomers worked as members of large project teams in order to accomplish satellite missions. In contrast to the individualistic, research orientation of the science during the pre-space days, astronomers now have to involve themselves in complex engineering tasks, meet large financial responsibilities, and manage larger staffs.

A related structural effect on astronomy is its fractioning into a group of related but quite distinct sciences. Each of the sub-fields has as many or more personnel as the whole of astronomy did a generation ago. This segmentation of the science has been accompanied by more complex funding arrangements; federal funds now flow through NASA research centers, national observatories, universities, and other nongovernmental corporations. The specialization within the science, the influx of new manpower, and more intricate funding arrangements require more effort on the part of astronomers to set priorities, establish coordinated efforts, and manage effective programs.

In summary, NASA's large expenditures of over $100 million annually for basic research alone and the stimulus provided by space exploration have dramatically transformed astronomy. It has become a more open science with more numerous facilities, research opportunities, and scientists. Younger astronomers with more diverse educational backgrounds have been attracted from other scientific fields to work in several new specialties that have developed. More complex management and funding arrangements and large project efforts demonstrate that astronomy has achieved big science status.

Footnotes

1. Ronald Konkel and Mary Holman. *Economic Impact of the Manned Space Flight Program.* Washington, D.C.: National Aeronautics and Space Administration, January 1967.

2. Midwest Research Institute. "Technological Progress and Commercialization of Communications Satellites." In: *Economic Impact of Stimulated Technological Activity.* Kansas City, Missouri: Midwest Research Institute, November 1971.

3. D. Interaglia. "The U.S. International Record Carrier: Past, Present, and Future." New York: Pace College, Master's Thesis, February 1972.

4. See footnote 2, pp. 54-59.

5. R. Jastrow and H. Newell. "The Space Program and the National Interest." *Foreign Affairs.* April 1972.

6. The history and operation of NASA's Technology Utilization Program are discussed in: R. Lesher and G. Howick. *Assessing Technology Transfer.* Washington, D.C.: National Aeronautics and Space Administration, 1966; S. Doctors. *The Role of Federal Agencies in Technology*

Transfer. Cambridge, Mass: MIT Press, 1968, p. 69; R. Rosenbloom. "The Transfer of Space Technology." In: R. Bauer (ed). *Second-Order Consequences.* Cambridge, Mass: MIT Press, 1969; and J. Geise. *The Role of the Regional Dissemination Centers in NASA's Technology Utilization Program.* Washington, D.C.: National Aeronautics and Space Administration, May 1971.

7. Denver Research Institute. *The Commercial Application of Missile/Space Technology.* Denver, Colorado: Denver Research Institute, September 1963. Also: J. Wells and R. Waterman. "Space Technology: Pay-Off from Spin-Off." *Harvard Business Review.* July-August 1964.

8. Denver Research Institute. *Mission-Oriented R&D and the Advancement of Technology: The Impact of NASA Contributions.* Denver, Colorado: Denver Research Institute, May 1972.

9. Mathematica, Inc. "Quantifying the Benefits to the National Economy from Secondary Application of NASA Technology." Princeton, N.J.: Mathematica, Inc., June 1975.

10. The case study of astronomy was carried out by Professor James Kuhn of Columbia University. See: E. Ginzberg, J. Kuhn, J. Schnee, and B. Yavitz. *Economic Impact of Large Public Programs: The NASA Experience.* Salt Lake City: Olympus Publishing, 1976, pp. 81-113.

History

Teaching Experiences and Syllabus

Walter A. McDougall
Woodrow Wilson Center for Scholars
Smithsonian Institution

I. Teaching Experiences

I have had two experiences teaching space history. The first experience resulted from a stretching of a lecture course in twentieth century diplomatic history up to 1968. Among the new lectures were two directly involved with the relationships among international politics, war, and government organization for the promotion of technological change, and also how World War II and the Cold War accelerated the pace of scientific and technological development. Lectures also addressed the origins and impact of Sputnik around the world, describing the immense and diverse effects of Sputnik on politics, economics, and diplomacy in Asia and Europe as well as the U.S.A. and U.S.S.R. The students were very enthusiastic and grateful for the knowledge; they thirst for postwar history.

My second experience was a freshman/sophomore seminar on "The Dawn of the Space Age" at the University of California at Berkeley. Interest in the seminar was widespread—about twenty-five students sought the fifteen places.

The class discussed a specified historical problem associated with space history each week. The syllabus was compiled from hundreds of pages of original government documents I had collected during research trips to NASA and the Presidential libraries. The students were fascinated by the government documents, but unable to do much in the way of primary source criticism. Students also had difficulty thinking historically about the evolution of space policy; they constantly wanted to discuss the future, such as space colonies, industrialization, and weaponry.

Students researched and submitted term papers on the following topics:

(1) Effects of history on the prospects of future space programs;
(2) The media and space;
(3) Management of the aerospace industry;
(4) Solar power satellites and the energy crisis;
(5) Perceptions of the enemy in nuclear strategy—the case of Sputnik;
(6) Communist ideology and the space policy of the U.S.S.R.;
(7) Space technologies and disarmament;
(8) NASA/DoD relations, present and future;
(9) A history of communications satellites; and
(10) Long-term effects of Apollo on the U.S. space program.

II. Syllabus

University of California, Berkeley
Course: The Dawn of the Space Age
Instructor: Dr. Walter McDougall

Description

Twenty-three years ago the first man-made object escaped the Terran biosphere. The Russian Sputnik I changed the world as no other event since 1945. In the very near future we will enter the age in which there will always be human beings—first some, later many—living permanently in space. As is the case in all human breakthroughs into unexploited technological, geographical, or ecological "terrain," long-range patterns of use and management of outer space technology evolved according to policies and programs that reflected the historical setting of the "breakthrough" years. This seminar will examine the historical origins of the space age and United States space policy, seeking those patterns that define the present and constrain the future of humans and machines in space. Major themes are the tensions between cooperation and competition in space; military vs. civilian control; conflict among scientific, economic, military, and prestige motives; and the larger issue of choice vs. political or technological determinism in human affairs. Requirements for the course include curiosity about the origins of the contemporary world, a willingness to do a large amount of reading . . . and imagination.

Class Schedule

Week 1:	Class:	*The Shadow of WWII: Cold War and Technology*
	Reading:	Hammond, chaps. 1-4; von Braun, chaps. 1-5.
Week 2:	Class:	*The Shock of Sputnik: The Domestic Setting*
	Reading:	McDougall, pp. 1-64; von Braun, chaps. 6-7; William, introduction and chap. 1.
	Paper:	"The Psychology of Sputnik"
Week 3:	Class:	*Foreign Policy Fallout: U.S., Europe, and the Third World*
	Reading:	Daniloff, chaps. 1-4; Eisenhower, chaps. 8-10; McDougall, pp. 65-89; Hammond, chap. 5.
Week 4:	Class:	*The Missile Gap: U.S. Organizes for the Space Age*
	Reading:	McDougall, pp. 90-177; Killian, pp. 20-39, 55-150, 237-261; Anderson, chaps. 1-2.
Week 5:	Class:	*The Birth of Project Apollo*
	Reading:	Logsdon, pp. 1-130; McDougall, pp. 178-189.
Week 6:	Class:	*The Military in Space: Strategy in the Missile Age*
	Reading:	Brodie (entire); York (entire); McDougall, pp. 190-217.
Week 7:	Class:	*The Space Race and Its Critics*
	Reading:	McDougall, pp. 218-242; Etzioni (entire); Vladimirov (entire).
	Paper:	"The Space Debate: What Was at Stake?"
Week 8:	Class:	*Space Law: From Sputnik to the Space Treaty*
	Reading:	McDougall, pp. 247-374; Lovell (entire); Bloomfield, chaps. 6-7.
Week 9:	Class:	*The Human Side: Astronauts and the Public*
	Reading:	Wolfe (entire) or Collins (entire); Anderson, chaps. 3-5.
Week 10:	Class:	*Space Politics: The History and Future*
	Reading:	Bloomfield, introduction and chap. 8; McDougall, pp. 375-393.
	Paper:	Essay on a space topic of your choosing (e.g., the European space programs, the Russian military space effort, the organization of Intelsat, the NASA international program, the politics of aerospace contracts).

Required books

Frank Anderson. *Orders of Magnitude. A History of NACA and NASA.*
Bernard Brodie. *Strategy in the Missile Age.*
Paul Hammond. *Cold War and Detente: The American Foreign Policy Process Since 1945.*
John Logsdon. *The Decision to Go to the Moon.*

Bernard Lovell. *The Origins and International Economics of Space Exploration.*
Walter McDougall. Xeroxed syllabus.
Tom Wolfe. *The Right Stuff.*
Herbert York. *Race to Oblivion.*

Reserve

All of the above, plus:
Lincoln Bloomfield (ed). *Outer Space, Prospects for Man and Society.*
Nicholas Daniloff. *The Kremlin and the Cosmos.*
Dwight Eisenhower. *Waging Peace 1956-1961.*
Amitai Etzioni. *The Moon-Doggle.*
Louis Halle. *The Cold War as History.*
James Killian. *Sputnik, Scientists, and Eisenhower.*
Leonid Vladimirov. *The Russian Space Bluff.*
Wernher von Braun. *History of Rocketry and Space Travel.*

Report on a Yale University Course and the Course Syllabus

Alex Roland
History Department
Duke University

I. Report on the Course

The idea and title for this course came from the students of Yale, specifically the students of Calhoun and Jonathan Edwards colleges. These students sponsored the course as part of Yale's college seminar program that can bring outside teachers into the university to teach courses that are of interest to the students but are not normally available in the catalogue. At the request of the students, I prepared a tentative course syllabus and went to Yale to meet with a student committee. To my surprise, the students asked me to increase the reading for the course; I later learned that they did this to ensure that the course would appear sufficiently rigorous to survive the close scrutiny that the Yale faculty normally gives to courses offered by outsiders. As it turned out, the reading for the course was probably more than the students could handle.

At Yale's suggestion, the course was limited to a maximum of eighteen students. Students submitted sixty-nine applications, and most included a summary of the students' reasons for wanting to take the course. A wide variety of majors was represented, with the heaviest representation in the physical sciences and engineering.

The most remarkable characteristic of the students was their naive but insatiable enthusiasm for the topic. All were by definition post-Sputnik babies (born in 1958 or later), children of the space age and products of its climate. The Apollo program occurred at the formative period in their lives, and it affected them deeply. They looked on the space program uncritically—in fact without much serious thought at all—as a boon to mankind and an indispensable national adventure from which we should not retreat. The course informed and chastened this enthusiasm, but was powerless to either dampen or deter it. The students were space cadets when we started and space cadets when we finished.

As the course description explains, the twelve weekly meetings addressed three principal topics. The first two classes examined the origins of space activity and the creation of NASA. The middle eight meetings reviewed NASA activities in the Apollo era from a variety of perspectives, such as politics, management, technology, science, and international cooperation. The goal here was to demonstrate how complicated such a program is and how many variables influence decisions. The last two class meetings were devoted to the history of NASA since Apollo and the future of the American space program. A fluke in scheduling produced a thirteenth meeting, which we used to review the course and try to summarize American space policy.

If this course is taught again, instructors should add or substitute class meetings devoted exclusively to the American military space program and the Russian space program (perhaps including brief surveys of Japanese, Chinese, and European programs).

The class met once a week for two and one-half hours. Lectures at the beginning of each class provided background information and put the reading in context. Then the students who had book reports due made their presentations. General discussion followed for the remainder of the available time.

Often lectures were longer than would have been preferable, because available literature did not adequately present all the material to be covered. The students tended to summarize books rather than criticize them, leading to overly long and unanalytical book reports. The discussions were always lively and productive.

The course had no examinations. Grades were based on the book reports, class discussions, and a term paper of 15-25 pages. The syllabus called for two papers, but in practice all the students prepared a preliminary paper at mid-semester for instructor critique. The preliminary paper then became the basis of a more refined and sophisticated final paper. Paper topics included the decay of Skylab, exobiology, the military uses of the Space Shuttle, radiation hazards to astronauts, nuclear auxiliary power in space, life support systems, and remote sensing.

Although some of the topics originally proposed by the students were naive, simplistic, or impractical, most students settled on worthwhile subjects with a minimum of counseling. As would be expected, the quality of papers varied (though most were good or better). In general, the engineering and physical science majors had more difficulty mastering the techniques of historical analysis than other students, tending to focus descriptively on events without considering in sufficient depth how and why the events had happened. Still, most of the students gained at least a familiarity with the historical analysis method, and some even developed a modest facility for the approach.

The student response to the course was enthusiastic, and student evaluations were uniformly high. That analysis mirrors my own response: I think the course was a rewarding and worthwhile experience for me and the students.

A critique of the course would have to note that materials were the major problem. There is no good text that collects the material covered by the course, so the readings were assembled from a wide variety of sources that taxed the holdings of even so fine a repository as the library at Yale. Most college libraries couldn't begin to provide all the readings listed in the syllabus.

Even at Yale the reading arrangements were not entirely satisfactory. Because the students had to go to the library to read reserve materials, students were often inconvenienced, or even precluded from doing the required reading on time. Furthermore, not all of the assigned readings were as effective as anticipated. The reading list thus should be revised somewhat, and more of the material should be in a form that the students could buy or at least take out of the library.

The scarcity of materials also affected the preparation of research papers. For many of the students in this course, a constraint on the selection of a term paper topic was the availability—or rather absence—of adequate source materials.

In conclusion, this experience at Yale suggests that space activity is a valid and fruitful topic of study that taps considerable student interest, especially among the generation currently in college. The greatest obstacle to presenting such a course is the paucity of published materials for reading and research.

II. Syllabus

Yale University
Course: NASA and the Post-Sputnik Era
Instructor: Alex Roland

Description

This description and syllabus set out the purpose and structure of the seminar and list the required reading. Students will be responsible for completing the required reading before each class meeting. In addition, each student will report sometime during the semester on one of the books listed for report on the syllabus. The instructor will report on the books listed for the second seminar meeting as well as any other books for which there are no student volunteers.

The instructor will introduce each seminar meeting with a brief lecture, followed by one or more book reports of ten to fifteen minutes to be made by students. The remainder of the meeting will be given over to discussion.

In addition to the readings and book reports, each student will prepare two research papers on topics chosen by the student and approved by the instructor. Proposed topics should be submitted to the instructor for approval at the third class meeting.

Grading will be based on class participation, book reports, and the two research papers.

This course will examine the U.S. civilian space program from its inception in the wake of Sputnik up to the present concerns with the Space Shuttle and harvesting the practical returns on America's space exploration, research, and development. The objective is to evaluate the program and the national policies it has represented, measure its impact on the contemporary world, and consider its future course and implications. Is the Moon landing, as Arthur Schlesinger, Jr., has suggested, likely to be viewed by future generations as the most important event of the twentieth century, or was it, as Amitai Etzioni has asserted, merely a "moon-doggle," lacking both significance and worth?

Since NASA is the vehicle and the embodiment of America's space program, it will be the focus of the course. The first two classes will examine how and why the space agency was created. Emphasis will be given to the strategic considerations that led to the development of large launch vehicles and to the military and political considerations that brought the United States into a space race with the Soviet Union. The military origins and implications of space travel complicated the establishment of NASA and have continued in the ensuing years to cast an ominous shadow over America's commitment to the peaceful uses of outer space.

The next eight seminar meetings will examine the Apollo program, with which NASA and the American civilian space program are still most widely associated. Each meeting will deal with one factor of Apollo decisionmaking and policy formulation. The result will be a composite of the disparate and often conflicting considerations that shaped the Apollo program. Meeting three will examine the politics of Apollo, from the Cold War enthusiasms behind the decision to go to the Moon to the Vietnam War and the greening of America that made the Moon mission look to some like a misguided squandering of national treasure. Meeting four on the technology of Apollo will contrast what some have called the greatest technological feat of modern times with the degree to which most of the technology required was actually available at the outset. Meetings five through nine will treat the communities and institutions that affect or are affected by the NASA program, ranging from the White House, the Department of Defense, and Congress through the aerospace industry, the public, and the scientific community. Meeting ten will deal with the space programs of foreign countries, especially the Soviet Union, and the record of international cooperation in space.

With this grounding in the how and why of the American civilian space program, the seminar in the final two meetings will examine the program since Apollo, evaluate the first twenty years, and look at the prospects for the future. Meeting eleven will be built around the conceptual tools proposed in Raymond A. Bauer's *Second-Order Consequences,* an attempt to look beyond the obvious and immediate impact of NASA's programs. The final meeting will use an assessment of the space program to date as a tool for predicting the future. Among the major issues to be addressed are the contrast between the tangible and the symbolic results of the program, the relative growth of military activities in space, and the merits of civilian space activity as a national undertaking.

(1) Background to Sputnik

Early rocket technology; the German rockets of World War II; the development of ICBMs in the Cold War; the International Geophysical Year, 1957-58; the technology of spaceflight.

Reading:

Frank W. Anderson, Jr. *Orders of Magnitude: A History of NACA and NASA, 1915-1976.* Washington, 1976.

(2) Sputnik and the Birth of the American Space Program

The reaction of Eisenhower, Congress, the military, NACA, the scientific community, the press, and the public; drafting and passage of the Space Act.

Reading:

Enid Bok Schoetle. "The Establishment of NASA." In: Sanford A. Lakoff (ed). *Knowledge and Power: Essays on Science and Government.* N.Y., 1966, pp. 162-270.

Edwin Diamond. *The Rise and Fall of the Space Age.* Garden City, N.Y., 1964, chaps. 1-2.

Herbert York. *Race to Oblivion: A Participant's View of the Arms Race.* N.Y., 1970, chap. 6.

Gabriel A. Almond. "Public Opinion and the Development of Space Technology." In: Joseph M. Goldsen (ed). *Outer Space and World Politics.* N.Y., 1963, pp. 71-96.

Book Reports:

Alison Griffith. *The National Aeronautics and Space Act: A Study of the Development of Public Policy.* Washington, 1962.

Mary Stone Ambrose. "The National Space Program, Phase I: Passage of the National Aeronautics and Space Act." American University, M.A. thesis, 1960.

(3) The Politics of Apollo

The space race; the Apollo decision; manned vs. unmanned spacecraft; criticisms of Apollo; Congressional budget cuts.

Reading:

Philip A. Abelson. "The Space Race." *American Psychologist.* Vol. 19, 1964, pp. 39-45.

Alton Frye. "Politics: The First Dimension of Space." *Journal of Conflict Resolution.* Vol. 10, March 1966, pp. 103-16.

Mose L. Harvey. "Preeminence in Space: Still a Critical National Issue." *Orbis.* Vol. 12, 1969, pp. 959-83.

Vernon Van Dyke. *Pride and Power: The Rationale of the Space Program.* Urbana, Ill., 1964, chaps. 8-10.

Book Reports:

John Logsdon. *The Decision to Go to the Moon: Project Apollo and the National Interest.* Cambridge, Mass., 1970.

Amitai Etzioni. *The Moon-Doggle: Domestic and International Implications of the Space Race.* Garden City, N.Y., 1964.

(4) The Technology of Apollo

An engineering problem of known dimensions: launch vehicle, spacecraft, communications, astronauts.

Reading:

John Noble Wilford. *We Reach the Moon.* N.Y., 1969, chaps. 10-13.

John Logsdon. "Selecting the Way to the Moon: The Choice of the Lunar Orbital Rendezvous Mode." *Aerospace Historian.* Vol. 18, June 1961, pp. 63-70.

Hilliard W. Paige. "Technology of Manned Return from Outer Space." *Journal of the Franklin Institute.* Vol. 267, 1959, pp. 103-18.

S.F. Hoffman. "Large Rocket Engines for Space Vehicles and Missiles." *Journal of the Royal Aeronautical Society.* Vol. 65, 1961, pp. 321-31.

Nicholas E. Golovin. "Systems Reliability in the Space Program." *Industrial Quality Control.* Vol. 20, May 1964, pp. 20-30.

Book reports:

Courtney G. Brooks, James M. Grimwood, and Loyd S. Swenson. *Chariots for Apollo: A History of Manned Lunar Spacecraft.* Washington, 1979.

Charles D. Benson and William Barnaby Faherty. *Moonport: A History of Apollo Launch Facilities and Operations.* Washington, 1978.

(5) NASA and the Executive Branch

NASA relations with the White House, especially the National Aeronautics and Space Council, the Office of Management and Budget, and the President's Special Assistant for Science and Technology; NASA's relations with other federal agencies, especially the Department of Defense.

Reading:
"White House Superstructure for Science." In: William R. Nelson (ed). *The Politics of Science.* N.Y., 1968, pp. 107-23.

Alan L. Dean. "Mounting a National Space Program." In: *Science and Resources: Prospects and Implications of Technological Advance.* Baltimore, 1959, pp. 219-27.

Van Dyke. *Pride and Power,* chaps. 3, 4, and 12.

Diamond. *Rise and Fall of the Space Age,* chap. 7.

Erlend A. Kennan and Edmund H. Harvey, Jr. *Mission to the Moon: A Critical Examination of NASA and the Space Program.* N.Y., 1969, chap. 10.

Hugo Young, Bryan Silcock, and Peter Dunn. *Journey to Tranquility.* Garden City, N.Y., 1970, chap. 7.

Book reports:
James R. Killian, Jr. *Sputnik, Scientists and Eisenhower: A Memoir of the First Special Assistant to the President for Science and Technology.* Cambridge, Mass., 1977.

George B. Kistiakowsky. *A Scientist at the White House: A Private Diary of President Eisenhower's Special Assistant for Science and Technology.* Cambridge, Mass., 1976.

(6) NASA and Congress

Congressional committee structure on space matters; oversight; policy formulation; the budgetary process; interest group politics.

Reading:
James R. Kerr. "Congress and Space: Overview or Oversight." In: Nelson. *Politics of Science.* 1968, pp. 176-89.

Thomas P. Murphy. "Congressional Liaison: The NASA Case." *Western Political Quarterly.* Vol. 25, 1972, pp. 192-214.

Kennan and Harvey. *Mission to the Moon,* chap. 12.

Eileen Galloway. "Scientific Advice for Congress: Analysis of Three Proposals." In: Lakoff (ed). *Knowledge and Power.* 1966, pp. 359-76.

Book reports:
R. Cargill Hall. *Lunar Impact: A History of Project Ranger.* Washington, 1977.

Thomas P. Jahnige. "Congress and Space: The Committee System and Congressional Oversight of NASA." Claremont Graduate School and University Center, Ph.D. dissertation, 1965.

(7) The Management of Large Scale Technology

Contracting with the aerospace industry; management practices within NASA.

Reading:
H. L. Nieburg. *In the Name of Science.* Chicago, 1966, chaps. 10-17.

Wernher von Braun. "Management of Manned Space Programs. In: F.E. Kast and J.E. Rosenzweig (eds). *Science, Technology, and Management.* N.Y., 1963, pp. 246-63.

Book reports:
James E. Webb. *Space Age Management: The Large Scale Approach.* New York, 1969.

W. Henry Lambright. *Governing Science and Technology.* N.Y., 1976.

(8) NASA and the Public

"If we can go to the Moon, why can't we . . .?" Public perceptions and misperceptions of NASA and the space program; the astronaut as hero.

Reading:
Any *one* of the books from the book report list, plus:

Michael P. Richard. "Space and Public Opinion." *Sociology and Social Research.* Vol. 49, 1965, pp. 437-45.

Book reports:
Norman Mailer. *Of a Fire on the Moon.* Boston, 1970.

Tom Wolfe. *The Right Stuff.* N.Y., 1979.

Michael Collins. *Carrying the Fire: An Astronaut's Journeys.* N.Y., 1974.

(9) NASA and the Scientific Community

Big science vs. small science; who controls: NASA or the scientific community; scientists vs. engineers vs. managers; basic vs. applied research.

Reading:
Donald A. Strickland. "Physicists' Views of Space and Politics." *Public Opinion Quarterly.* Vol. 29, 1965, pp. 223-35.

Norriss A. Heatherington. "Winning the Initiative: NASA and the U.S. Space Science Program." *Prologue.* Vol. 7, 1975, pp. 99-107.

Gordon J.F. MacDonald. "Science and Space Policy: How Does It Get Planned?" *Bulletin of the Atomic Scientists.* Vol. 23, May 1967, pp. 2-9.

William F. Pickering. "Selection of Space Experiments." *American Scientist.* Vol. 54, 1966, pp. 103-109.

William F. Pickering. "Grand Tour." *American Scientist.* Vol. 58, March 1970, pp. 148-55.

Ian A. Mitroff. "On Doing Empirical Philosophy of Science: A Case Study in the Social Psychology of Research." *Philosophy of the Social Sciences.* Vol. 4, 1974, pp. 183-96.

Ian A. Mitroff. "On the Norms of Science: A Report of a Study of the Apollo Moon Scientists (1)." *Communication and Cognition.* Vol. 7, 1974, pp. 125-51.

Lyman Spitzer, Jr. "Beginnings and Future of Space Astronomy." *American Scientist.* Vol. 50, 1962, pp. 473-84.

Book reports:
Homer Newell. *Beyond the Atmosphere: The Early Years of Space Science.* Washington, 1980.

National Research Council, Space Science Board. *Opportunities and Choices in Space Science, 1974.* Washington, 1975.

(10) International Cooperation

The space programs of other nations; American policies on joint activities in space; the Apollo-Soyuz Test Project.

Reading:
Arnold Frutkin. *International Cooperation in Space.* Englewood Cliffs, N.J., 1965.

Book reports:
Edward Clinton Ezell and Linda Neuman Ezell. *The Partner ship: A History of the Apollo-Soyuz Test Project.* Washington, 1978.

Don E. Kash. *The Politics of Space Cooperation.* Lafayette, Ind., 1967.

(11) NASA After Apollo

Aeronautics; space science; Earth applications; Skylab; the Space Shuttle; the impact of space; meteorology, communications, Earth resources.

Reading:
Raymond A. Bauer. *Second-Order Consequences: A Methodological Essay on the Impact of Technology.* Cambridge, Mass., 1969.

Allan H. Brown. "The Post-Apollo Era: Decisions Facing NASA." *Bulletin of the Atomic Scientists.* Vol. 23, April 1967, pp. 11-16.

Book reports:
Mary A. Holman. *The Political Economy of the Space Program.* Palo Alto, CA, 1974.

Frederick I. Ordway, Carsbie C. Adams, and Mitchell R. Sharpe. *Dividends from Space.* N.Y., 1971.

(12) The Future of the American Space Program

The relation of the military and civilian programs; space as a discretionary government activity; the Space Shuttle.

Reading:
NASA. *Outlook for Space: Report to the NASA Administrator.* Washington, 1976.

R. Jeffrey Smith. "Shuttle Problems Compromise Space Program." *Science.* Vol. 206, Nov. 23, 1979, pp. 910-14.

Book reports:
Gerard K. O'Neill. *The High Frontier: Human Colonies in Space.* N.Y., 1976.

Arthur L. Levine. *The Future of the U.S. Space Program.* N.Y., 1975.

International Law and Relations

U.N. Purposes and Organization, Suggested Bibliography, List of Selected International Agreements, and List of Signatories to Selected International Agreements

Harold M. White, Jr.
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I. U.N. Purposes and Organization

Article I of the U.N. Charter defines the purposes of the organization:

(1) To maintain international peace and security, and . . . to take effective collective measures . . . in conformity with principles of justice and international law . . . (to bring about) adjustment or settlement of international disputes.

(2) To develop friendly relations among nations based on respect for the principle of equal rights and self-determination of peoples.

(3) To achieve international cooperation in solving international problems of an economic, social, cultural or humanitarian character, and in promoting and encouraging respect for human rights and for fundamental freedoms for all without distinction as to race, sex, language, or religion.

(4) To be a center for harmonizing the actions of nations in the attainment of these common ends.

The central organ of the United Nations is the General Assembly, which might be loosely compared to an international parliament. Each member nation exercises one vote, although as many as five representatives can be delegated to the Assembly. In theory, the Assembly's actions do not carry the force of law, but rather a moral weight derived from their assumed representation of the consensus of nations. However, in practice, the General Assembly has achieved somewhat more influence than is generally recognized.

An example of this influence is the "Uniting for Peace Resolution." In the original United Nations concept, the Security Council possessed sole executive authority to levy sanctions, dispatch peacekeeping forces, enunciate "binding" international law, or even engage in collective military action. At that time, a nine-vote majority of the fifteen-member Council was required, although action could be vetoed by two negative votes from the five permanent members: the United States, Britain, France, China, and the Soviet Union. However, the Soviet Union insisted on a one-veto Council, a rule which has shackled the Council. Nevertheless, the United States devised a bypass to this block during the Korean War. The U.S. postulated that a general resolution might lend the color of international legitimacy to a voluntary association of states intervening in a state of hostilities such as those in Korea. The "Uniting for Peace Resolution" thus fell under voting provisions for membership matters and business sufficiently "important" to refer out of the Security Council, i.e., passage by a two-thirds majority. The General Assembly also adopts the general budget, assesses members, and establishes associated committees and subsidiary organizations on questions of specialty. The Committee on the Peaceful Uses of Outer Space is one such committee.

The Secretariat undertakes administrative functions for the United Nations organs, committees, and some of the specialized agencies. The Secretary General must be nominated by the Security Council and elected by the General Assembly.

The International Court of Justice exercises only permissive jurisdiction. For example, jurisdiction in the case of the Iranian hostages was legitimized only because both parties previously had agreed to an international diplomatic convention. The outcome of such cases may generate enormous diplomatic, political, or even moral impact; nonetheless, it is obvious that practical enforceability of judgments either requires the assent of the charged party or awaits future developments.

The Trusteeship Council administers the orderly transition of former colonies or other unorganized regions to independent, self-governing status. The Trusteeship Council has nearly completed its initial work, so the Council may be phased out or may be molded into the tutor for future internationally constituted space habitats.

The Economic and Social Council addresses the myriad problems of the world by encouraging the development and coordinating the work of specialized agencies. Each specialized agency is independently constructed based upon a separate treaty. The agencies work in their own fields and cooperate with the U.N., pursuant to an agreement defining the relationship. The United Nations, in contrast to the old League of Nations, did not seek to bring all international activities into one rigid system. Although most of the specialized agencies are similarly organized, each is an independent, international legal entity, with its own legislative body and secretariat. Specialized agencies are destined to play an increasingly vital role, especially in the field of astronautics, which requires a high level of specialized expertise.

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Myres S. McDougal, Harold D. Lasswell, and Ivan A. Vlasic. *Law and Public Order in Space.* New Haven: Yale Press, 1963.

Jerome Morenoff. *World Peace Through Space Law.* Charlottesville: Michie, 1967.

George Robinson and Jerome Glenn. *Space Trek.* Harrisburg: Stackpole, 1978.

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Paul Williams (ed). *The International Bill of Human Rights.* San Francisco: Entwhistle, 1981.

III. List of Selected International Agreements*

Aerosat Memorandum of Understanding. August 2, 1974.

The Agreement of the Arab Corporation for Space Communications.

Agreement on the Constitution of a Provisional European Telecommunications Satellite Organization, "Interim Eutelsat."

Agreement Between the National Aeronautics & Space Administration (NASA) and McDonnell-Douglas Astronautics Company for a Joint Endeavor in the Area of Material Processing in Space. January 25, 1980.

Agreement on the Establishment of the "Intersputnik" International System and Organization of Space Communications.

Agreement on Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes. Moscow: July 13, 1976.

Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space. December 3, 1968.

Convention for the Establishment of a European Space Agency. May 30, 1975.

Convention on the International Maritime Satellite Organization (Inmarsat) and the Operating Agreement. Date of Signature: September 3, 1976.

Convention on International Liability for Damage Caused by Space Objects. October 9, 1973.

Convention on the Registration of Objects Launched into Outer Space. September 15, 1976.

Convention on the Transfer and Use of Data on the Remote Sensing of the Earth from Outer Space. Moscow: May 19, 1978.

Declaration and Programme of Action on the Establishment of a New International Economic Order. December 12, 1974.

Draft Principles on Direct Broadcast Satellites in the U.N. Committee on Peaceful Uses of Outer Space. 1977.

Final Acts of WARC 1979.

International Telecommunications Convention and Radio Regulations. 1973.

International Telecommunications Satellite Organization (Intelsat) Agreement and Operating Agreement. February 12, 1973.

OECD Convention on Protection of Individuals with Regard to Automative Processing of Personal Data. September 19, 1980.

OECD Guidelines on Protection of Privacy in Relation to Transborder Data Flows of Personal Data. September 23, 1980.

Report of the International Commission for the Study of Communications Problems. The MacBride Commission: 1980.

Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under Water. October 10, 1963.

Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies. October 10, 1967.

United Nations Charter.

United Nations General Assembly Resolutions on: Information 3535 (XXX) of December 17, 1975; 31/139 of December 16, 1976; 33/115 of December 18, 1978; 34/181 and 182 of December 18, 1979.

UNESCO Declaration of 1972: The Declaration Guiding Principles on the Use of Satellite Broadcasting for the Free Flow of Information, the Spread of Education and Greater Cultural Exchange.

U.S.S.R. Convention on Principles Governing the Use By States of Artificial Earth Satellites for Direct Television Broadcasting.

*Joseph Pelton. AIAA Conference on Large Space Platforms. San Diego, California, April 1981.

IV. List of Signatories to Selected International Agreements*

In order to present the current state of affairs more clearly with regard to the consent of states to be bound by treaties governing activities in outer space, I have prepared a chart showing the situation as of January 1, 1979. It contains, in alphabetical order, a list of states, parties and potential or possible parties to the agreements in question. Non-members of the United Nations are marked by an "(x)"; international organizations have not been included as parties or possible parties to the agreements because I did not consider this to be relevant for this occasion. The following letters have been used in order to show that a particular state is bound by a respective agreement:

"P" for the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies;

"A" for the 1968 Agreement on the Rescue of Astronauts and the Return of Objects Launched into Outer Space;

"L" for the 1972 Convention on International Liability for Damage Caused by Space Objects;

"R" for the 1976 Convention on Registration of Objects Launched into Outer Space;

"I" for the 1971 Agreement Relating to the International Telecommunications Satellite Organization (Intelsat), with Annexes, and the respective Operating Agreement, with Annex;

"N" denotes whether a particular state had or has engaged in any form of cooperation with the United States National Aeronautics and Space Administration (NASA).

1.	Afghanistan					I	N
2.	Albania						
3.	Algeria					I	N
4.	Andorra (x)						
5.	Angola					I	N
6.	Argentina	P	A			I	N
7.	Australia	P		L		I	N
8.	Austria	P	A			I	N
9.	Bahamas	P	A				N
10.	Bahrain						N
11.	Bangladesh					I	N
12.	Barbados	P	A			I	N
13.	Belgium	P	A	L	R	I	N
14.	Benin			L			
15.	Bhutan						
16.	Bolivia					I	N
17.	Botswana		A	L			N
18.	Brazil	P	A	L		I	N
19.	Brunei (x)						
20.	Bulgaria	P	A	L	R		N
21.	Burma	P					N
22.	Burundi						
23.	Byelorussian SSR	P	A		R		
24.	Cameroon		A			I	N
25.	Canada	P	A	L	R	I	N
26.	Cape Verde						
27.	Central African Empire					I	N
28.	Chad					I	N
29.	Chile			L		I	N
30.	China					I	N
31.	Colombia					I	N
32.	Comoros						
33.	Congo					I	
34.	Costa Rica					I	N
35.	Cuba	P			R		N
36.	Cyprus	P	A	L	R	I	
37.	Czechoslovakia	P	A	L	R		N
38.	Denmark	P	A	L	R	I	N
39.	Djibuti						
40.	Dominica						
41.	Dominican Republic	P		L		I	N
42.	Ecuador	P	A	L		I	N
43.	Egypt	P	A			I	N
44.	El Salvador	P	A			I	N
45.	Equatorial Guinea						
46.	Ethiopia					I	N
47.	Fiji	P	A	L		I	N
48.	Finland	P	A	L		I	N
49.	France	P	A	L	R	I	N
50.	Gabon		A			I	N
51.	Gambia						
52.	German D.R.	P	A	L	R		N
53.	Germany, F.R. of	P	A	L		I	N
54.	Ghana					I	N
55.	Greece	P	A	L		I	N
56.	Grenada						
57.	Guatemala					I	N
58.	Guinea						
59.	Guinea-Bissau	P					N
60.	Guyana		A				N
61.	Haiti					I	N
62.	Honduras						N
63.	Hungary	P	A	L	R		N
64.	Iceland	P	A			I	N
65.	India					I	N
66.	Indonesia					I	N
67.	Iran		A	L		I	N
68.	Iraq	P	A	L		I	N
69.	Ireland	P	A	L		I	N
70.	Israel	P	A	L		I	N
71.	Italy	P	A			I	N
72.	Ivory Coast					I	N
73.	Jamaica	P				I	N

74.	Japan	P				I	N
75.	Jordan					I	N
76.	Kampuchea						N
77.	Kenya			L		I	N
78.	Korea (x)	P	A			I	N
79.	Korea, P.R. of (x)						
80.	Kuwait	P	A	L		I	N
81.	Laos	P	A	L			
82.	Lebanon	P	A			I	N
83.	Lesotho						N
84.	Liberia						
85.	Libya	P				I	N
86.	Liechtenstein (x)					I	
87.	Luxembourg					I	
88.	Madagascar	P	A			I	N
89.	Malawi						N
90.	Malaysia					I	N
91.	Maldives		A				N
92.	Mali	P		L		I	N
93.	Malta			L			
94.	Mauritania					I	
95.	Mauritius	P	A				N
96.	Mexico	P	A	L	R	I	N
97.	Monaco (x)					I	
98.	Mongolia	P	A	L			
99.	Morocco	P	A			I	N
100.	Mozambique						N
101.	Nauru (x)						
102.	Nepal	P	A				N
103.	Netherlands	P				I	N
104.	New Zealand	P	A	L		I	N
105.	Nicaragua					I	N
106.	Niger	P	A	L	R		
107.	Nigeria	P	A			I	N
108.	Norway	P	A			I	N
109.	Oman					I	N
110.	Pakistan	P	A	L		I	N
111.	Panama			L		I	
112.	Papua New Guinea						N
113.	Paraguay					I	N
114.	Peru					I	N
115.	Philippines					I	N
116.	Poland	P	A	L	R		N
117.	Portugal		A			I	N
118.	Qatar					I	N
119.	Romania	P	A				N
120.	Rwanda						
121.	Samoa						
122.	San Marino (x)	P	A				
123.	Sao Tome and Principe						
124.	Saudi Arabia	P		L		I	N
125.	Senegal			L		I	N
126.	Seychelles	P	A	L	R		N
127.	Sierra Leone	P					N
128.	Singapore	P	A	L		I	N
129.	Solomon Islands						
130.	Somalia						N
131.	South Africa	P	A			I	N
132.	Spain	P			R	I	N
133.	Sri Lanka			L		I	N
134.	Sudan					I	N
135.	Surinam						N
136.	Swaziland		A				N
137.	Sweden	P	A	L	R	I	N
138.	Switzerland (x)	P	A	L	R	I	N
139.	Syria	P	A			I	
140.	Taiwan (x)	P	A	L			N
141.	Tanzania					I	N
142.	Thailand	P	A			I	N
143.	Togo			L			
144.	Tonga (x)	P	A				N
145.	Trinidad and Tobago					I	N
146.	Tunisia	P	A	L		I	N
147.	Turkey	P				I	N
148.	Uganda	P				I	
149.	Ukrainian S.S.R.	P	A	L	R		
150.	U.S.S.R.	P	A	L	R		N
151.	United Arab Emirates					I	N
152.	United Kingdom	P	A	L	R	I	N
153.	U.S.A.	P	A	L	R	I	
154.	Upper Volta	P				I	N
155.	Uruguay	P	A	L	R		N
156.	Vatican (x)					I	
157.	Venezuela	P		L		I	N
158.	Viet Nam**					I	N
159.	Yemen					I	N
160.	Yemen, Democratic						
161.	Yugoslavia		A	L	R	I	N
162.	Zaire					I	N
163.	Zambia	P	A	L		I	N

If we sum these up, we shall obtain the following results:

P = 78
A = 70
L = 54
R = 24
I = 102
N = 122

It is evident that the four most important space treaties were taken into account. The Intelsat agreements were considered as examples of broadest cooperation within an international organization engaging in specific actions related to the practical application of space activities on a commercial basis, and cooperation with NASA as an example of broad international cooperation (mainly on a bilateral basis) with one of the most developed countries, in different fields of space activity—from mere personnel exchange, training and research work through cooperative projects, to joint experiments with sounding rockets or satellites (nevertheless, cases of cooperation with NASA are the most numerous in the field of meteorology). There is no doubt that the extension of the table with, say, data on other agreements in the field of telecommunication or other forms of multilateral international cooperation, such as Intercosmos, ESA, Intersputnik, Inmarsat, or bilateral arrangements, would offer additional objective information; at this point, however, I consider even this to be sufficiently representative and illustrative.

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**This refers to former South Viet Nam.

Philosophy

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George Farre
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Teaching Experience, Course Content, and Bibliography

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I. Teaching Experience

The National Science Foundation provided a grant to develop and teach an interdisciplinary course in the philosophy of space exploration. This course was team-taught in the spring of 1980 to a group of college students and pre-college science teachers in the Omaha area. The physics and philosophy departments granted three units of upper division credit.

Although the course addressed several interesting issues, the most important topic assessed the justification for space exploration in the face of strong demands for a reallocation of scarce resources (to hunger and poverty programs, for example). This crucial issue deserves a thoughtful and systematic treatment, because of both the magnitude of the resources and effort involved and the scientific and societal significance of the outcome.

Early in the development of the course, it became clear that an intelligent examination of relevant data required a careful discussion of prevailing assumptions about the nature and methodology of scientific knowledge. Such often questionable assumptions affect the weight assigned to the expansion of scientific knowledge through space exploration. For example, in this particular controversy, both sides assume that scientific understanding is cumulative or encyclopedic, without considering recent developments in the philosophy of science that counter that view. To steer the course away from a dry exercise in abstractions, the philosophy of science is illustrated extensively with examples from physics, astronomy, exobiology, and space science in general. This approach to the philosophy of science also facilitates student understanding of the significance of many prominent developments in space science. In this case, each discipline profits from the synergistic interactions.

This dual philosophical and scientific approach also examined the space program for illustrative purposes. In this context, the course focused particularly on the history of space exploration, prospects in the near future (with heavy emphasis on the Shuttle), and some interesting speculations about long-term possibilities.

The method of presentation for justification and other relevant issues might be called dialectical, encompassing the underlying reasons for a particular point of view, objections to that view, responses, and so on—until a final resolution, if possible. Of course, the success of this method depended on the students digesting sufficient materials on the nature and future of space exploration in general and space science in particular. This prerequisite material was introduced through readings, lectures, discussions, films, and other audio-visual aids. Most of the films are readily available from NASA, and slides are not difficult to obtain either (there is some overlap with astronomy and geography courses, and pictures of recent events in planetary exploration and of the Space Shuttle are abundant in many publications). However, the reading materials are a different matter altogether. No single source even begins to do justice to the aim of the course, although some sources adequately address specific issues (e.g., Gerard O'Neill's *The High Frontier* and R.M. Power's *Shuttle*). For the most part, lectures were compiled from a wide variety of sources.

The sixty-five students, including ten teachers and ten auditors, came with diverse backgrounds and interests. The course did not assume student knowledge of physics or philosophy and, consequently, aimed at the general student. Mathematical accounts of relativity and other topics were incorporated into the course, but in cases requiring a technical discussion, a parallel conceptual account was provided as well. The class met one evening a week, primarily to encourage school teacher attendance. In this three-hour meeting format, movies and slides produced a brisk pace; two instructors also minimized boredom. Team-teaching seems to work very well in a course of this type, a sentiment also expressed by the students in their final evaluation. In general, the course received very high marks in the evaluation conducted by the University's Center for Improvement of Instruction. Making the course easily available to school teachers added to the quality of the class and also encouraged a transfer of materials into elementary and secondary classrooms. One teacher's final project developed a teaching unit later adopted by the gifted elementary student program in her school district. A high school physics teacher constructed a teaching unit that allowed students to work out calculations relevant to building a space colony.

In view of the impact of the course, it has become a permanent feature of the University catalogue.

II. Course Content

The presentation of course material roughly corresponded with the following outline. The headings do not indicate equal distribution of time and/or attention.

(1) Introduction

(A) Preliminary overview of the course; the philosophical and scientific issues.

(B) Brief history of the space programs.
- (1) Rocket development
  - (a) Pioneers of spaceflight
  - (b) German space program
  - (c) Short history of American and Russian programs (much of the topic is handled elsewhere)

Main Source: William S. Bainbridge. *The Space Flight Revolution.*

Movie: "The Eagle Has Landed"

(C) Planetary research to present (emphasis on missions); near-future plans.

Main Sources: Historical and current accounts can be found in many readily available sources. For future plans, consult NASA's current five-year plan (for revisions and updates we favor publications in astronautics and the more general *Science*).

(D) Brief introduction to the Space Shuttle.

Main Source: Robert M. Powers. *Shuttle.*

(E) Informal class discussion of the motivations and reasons for space exploration.

(2) Initial Objections to Space Exploration

(A) In the face of the many pressing problems we have on Earth (e.g., poverty, starvation, disease, pollution) the expenditure of billions of dollars on space exploration cannot be justified.

Development of the objection.

(B) The environmentalist objection (for lack of a better and fairer name).

Space exploration gives false hope:

- (1) Space exploration is a continuation of the attempt to control the world rather than live in harmony with it.
- (2) We should face up to the fact that Earth is all we will ever have.

Main Sources: It is difficult to find well-developed statements of the objections. Sometimes they appear in journals like *Science.* The environmentalist objection really questions whether scientific knowledge is a positive value. Such arguments are presented in many forums, but perhaps the most accessible is: "Comments on O'Neill's Space Colonies." In: *Space Colonies.*

(3) First Response to the Objections

The NASA case for the economic, technological, and scientific benefits of past and current space programs (e.g., weather and communication satellites) and for the similar prospects of likely missions in the immediate future, with emphasis on the Space Shuttle. Special attention should be given to the following:

(A) Satellite systems (such as Landsat and Comsat).

(B) Spinoffs.

(C) Economic benefits of the space program.

(D) Space science.

(E) Possibilities for space industrialization.

Main Sources: A very good book at this introductory stage is: *Shuttle.* The sections on satellite systems and space science should be supplemented with the appropriate chapters from: *The Impact of Space Science on Mankind.* See also: Jesco von Puttkamer. "The Industrialization of Space." In: *Space Humanization Series.* Volume I, 1979. See also: NASA. *Spinoffs.*

(4) Further Objections

(A) The benefits derived from weather and communication satellites and the like constitute at best a case for a *limited* space program, but not a warrant for planetary exploration, manned missions to the Moon, and so on. This is not to deny that there are some scientific, adventure-oriented, and other values in such activity, but rather to pit the need for spending billions on finding a few facts about the backside of the Moon against improving the welfare of millions of human beings. That is to say, a space program limited in certain ways may lead to an improvement of the general welfare, but much of suggested space exploration would not necessarily or clearly accomplish that goal.

(B) Could secondary benefits of the space program (e.g., advances in medical technology) be achieved outright without investing in the enormous expense of the space program?

(C) Even in cases apparently helped by space technology (e.g., monitoring pollution), it is a mistake to employ more growth and technology to clean up the mess caused by growth and technology. A change of outlook against growth and technology altogether should be considered (which, of course, would not favor space exploration).

Main Source: There is no specific source for this second round of objections.

(5) A Preliminary Case for Space Exploration
Part I: Scientific Knowledge

(A) Contemporary philosophy of science and a non-cumulative view of scientific knowledge (Kuhn, Feyerabend, Lakatos). Tentatively: what is important for science is not just the collection of a few new facts, but the testing of advanced theories (which space exploration makes possible) and the opportunities for developing new ways of thinking about the world. If we fail to seize those opportunities, we will deprive ourselves of world views that might alert us to serious problems as well as identify solutions (not only to some of those problems, but also to other vexing issues).

(B) The relationship between theoretical advances and technological opportunities. The connection between the applied science resulting from a very complex enterprise (such as the space program) and beneficial technological spinoffs. Many such spinoffs would not have been possible through programs to develop them directly: they require the prior development of a certain point of view (examples from the history of physics, medicine, and the space program itself).

Main Sources: Hempel's *Philosophy of Natural Science* (for a standard approach to the subject) and Kuhn's *The Structure of Scientific Revolutions* (for the new approach). Much of the data about the nature of scientific knowledge came from Dr. Munévar's *Radical Knowledge.* These works presented difficulties for some students, so we made available several chapters from a manuscript by Dr. Munévar, *A Theory of Wonder: A Guide to the New Philosophy of Science.*

This section served as a general introduction; the discussion then shifted to specific illustrations of issues, manifested in several aspects of space exploration.

Movies: "HEAO—The New Universe"
"Moonflights and Medicine"

(6) A Preliminary Case for Space Exploration
Part II: Aspects of Space Exploration

(A) Planetary exploration and comparative planetology. Understanding the Earth as a member of a system. Learning more about the terrestrial environment by going into space: the role of the magnetosphere; weather systems (comparisons with Mars, Jupiter, and

Venus); plate tectonics (the frozen record of Ganymede); and so on. The short-term and long-term payoffs of planetary exploration.

Main Sources: Most standard textbooks in astronomy and geophysics will be helpful. Useful reports on recent planetary missions, particularly the Voyager missions, are included in *Scientific American* and *Science* (although quite technical). Also: "Voyager Views Jupiter's Dazzling Realm." *National Geographic.* January 1980.

Movies: "Voyager Jupiter Encounters 1979"
"Voyager 2—Jupiter Encounter"
"19 Minutes to Earth"

(B) Exobiology and its consequences for the philosophy of biology.

(1) Evolution of planets

(2) Evolution of life

(3) Conditions necessary for life to begin

(4) Likelihood of favorable planets throughout the galaxy

Main Sources: For an optimistic view: Carl Sagan (ed). *Communication With Extraterrestrial Intelligence.* For a different view: Thomas Heppenheimer. *Toward Distant Suns.*

(C) The search for intelligent life in the universe.

(1) Evolution of intelligence

(2) Evolution of technical civilizations

(3) Wisdom of communications

Main Sources: Communication With Extraterrestrial Intelligence. Also: criticism of the work drawn from several sources, including: *Radical Knowledge;* and S. Toulmin and J. Goodfield. *The Fabric of the Heavens.*

Movies: (in conjunction with previous section)
"Who's Out There?"
"Earth-Sun Relationship"
"Earthspace—Our Environment"

(D) Solar power satellites and other possible uses of space in the near future.

Main Sources: Shuttle; and *The High Frontier.* See also: *Toward Distant Suns.* All these materials must be updated with the NASA-DOE studies on the feasibility and environmental risks of SPS. Also: "Space Colonies"—four filmstrips.

(E) Space colonies.

(1) A springboard to human civilization away from Earth. The utilization of resources throughout the solar system. A way to avoid the "limits to growth?"

Main Sources: The High Frontier. Also: *Toward Distant Suns;* and Peter Vajk. *Doomsday Has Been Cancelled.*

(2) The parallels between past and future utopias:
(a) The Myth of the Metals and the status of women (from Plato's *Republic*) and the constitution of a space colony
(b) The proposal for homogeneous space societies in light of J.S. Mill's *On Liberty*

(F) The long-term future.

(1) Exploration of the galaxy
(a) The technologies involved; future propulsion systems
(b) The science involved; special and general relativity
(c) Associated problems in space-time physics and the philosophy of time and space. Time on ship. Tachyons. The problem of increases in mass.

(2) Possible new avenues of investigation in many areas of physics and astrophysics, including Einstein's general theory of relativity and its several alternatives. Quasars, black holes, and other strange things. Astronomy from space.

Main Sources: L.D. Jaffe, et. al.: "Science Aspects of a Mission Beyond the Planets"; "An Interstellar Precursor Mission"; and "Feasibility of Interstellar Travel." See also: P.C.W. Davis. *Space and Time in the Modern Universe.* See also a new book by: Saul and Benjamin Adelman. *Bound for the Stars.* For the novice in the field, a good source on relativity would be: William J. Kaufmann III. *The Cosmic Frontiers of General Relativity.*

Movies: "Universe"

(7) The Nature of Scientific Knowledge and the Justification Question

(A) Do we really have to confront the fact that Earth is the only resource and home we will ever have? Response to an environmentalist objection.

(B) The requirement of empirical growth, the evolutionary character of scientific knowledge, and the wisdom of science. A possible response to another environmentalist objection.

(C) The possible revolutionary windfall for physics, chemistry, and biology (and the concomitant windfall for technology). Final appraisal of the issue of justification.

Main Sources: This section is mainly a review, particularly of sections (5) and (6), and thus draws from the same sources. A useful addition might be: W. Brown and H. Kahn. *Long-Term Prospects for Development in Space (A Scenario Approach).*

Bibliography

(1) Required Books

Carl Sagan (ed). *Communication With Extraterrestrial Intelligence.* Cambridge, MA: MIT Press, 1973.

Gerard O'Neill. *The High Frontier.* New York: Bantam Books, 1978.

(2) Strongly Recommended Books

Tim Greve, Finn Lied, and Eric Tandbergg (eds). *The Impact of Space Science on Mankind.* New York: Plenum Press, 1976.

Robert M. Powers. *Planetary Encounters.* Harrisburg, PA: Stackpole Books, 1978.

Gonzalo Munévar. *Radical Knowledge.* Indianapolis, IN: Hackett, 1981.

Robert M. Powers. *Shuttle.* Harrisburg, PA: Stackpole Books, 1979.

Stewart Brand (ed). *Space Colonies.* New York: Penguin, 1977.

William S. Bainbridge. *The Space Flight Revolution.* New York: John Wiley and Sons, Inc., 1976.

Thomas S. Kuhn. *The Structure of Scientific Revolutions.* (Second edition.) Chicago, IL: University of Chicago Press, 1970.

Thomas Heppenheimer. *Toward Distant Suns.* Harrisburg, PA: Stackpole Books, 1979.

(3) Recommended Books

Thomas Heppenheimer. *Colonies In Space.* Harrisburg, PA: Stackpole Books, 1977.

William J. Kaufmann III. *The Cosmic Frontiers of General Relativity.* Boston, MA: Little, Brown and Company, 1977.

Peter Vajk. *Doomsday Has Been Cancelled.* Culver City, CA: Peace Press, 1978.

Carl C. Hempel. *Philosophy of Natural Science.* Englewood Cliffs, N.J.: Prentice Hall, 1966.

Jerry Glenn and George Robinson. *Space Trek.* Harrisburg, PA: Stackpole Books, 1978.

Nigel Calder. *Spaceships of the Mind.* New York: Viking Press, 1978.

A.H. Teich (ed). *Technology and Man's Future.* New York: St. Martin's Press, 1977.

(4) Other Books

Saul J. Adelman and Benjamin Adelman. *Bound for the Stars.* Englewood Cliffs, N.J.: Prentice Hall, 1981.

Carl Sagan. *Cosmos.* New York: Random House, 1980.

W. Brown and H. Kahn. *Long-Term Prospects for Development in Space (A Scenario Approach).* Washington, D.C.: NASA, 1977.

(5) Required Articles

NASA Five-Year Planning, 1980-1984.

"Voyager Views Jupiter's Dazzling Realm." *National Geographic.* Jan. 1980, pp. 2-29.

(6) Recommended Articles

Jesco von Puttkamer (NASA). "On Man's Role in Space."

Jesco von Puttkamer. "The Industrialization of Space." *Futurist.* June 1979.

Leonard D. Jaffe and Charles V. Ivie. "Science Aspects of a Mission Beyond the Planets." *Icarus 39.* 1979, pp. 486-494.

D.F. Spencer and L.D. Jaffe. "Feasibility of Interstellar Travel." *Astronautica Acta.* Vol. IX, 1963, pp. 49-58.

D.F. Spencer and L.D. Jaffe. "Advanced Propulsion Concepts—Proceedings of the Third Symposium." *Astronautica Acta.* Vol. IX, 1963.

L.D. Jaffe, et. al. "An Interstellar Precursor Mission." JPL Publication, pp. 70-77.

(7) Movies

"The Eagle Has Landed"
"Survival"
"Weather Watchers"
"Pollution Solution"
"4 Rms.—Earth View"
"If One Today—Two Tomorrow"
"HEAO—The New Universe"
"Moonflights and Medicine"
"Voyager Jupiter Encounters—1979"
"Voyager 2—Jupiter Encounter"
"Voyager 2—Jupiter Zoom Film"
"Who's Out There?"

Political Science

Course Syllabus and Sample Research Assignments

John M. Logsdon
Graduate Program in Science, Technology, and Public Policy
George Washington University

The course was taught during the Spring 1981 term at George Washington University to thirty-five undergraduates, mainly juniors and seniors. The course seemed to maintain student interest; before they attended the initial class meeting, students did not know that the focus of the course would be on space policy, and thus there was no pre-selection based on prior space interest. The goal of the course was to give students a detailed sense of how technology and politics interact, and the space area is both representative of broader decision issues in the technology politics area and inherently interesting to most students. Thus the course can be viewed as successful, in large part because of the use of space policy as a substantive focus for a broader examination of the decisionmaking process.

I. Syllabus

Course: Science, Technology, and Politics
U.S. Space Policy: Past, Present, and Future

This course is intended to increase your understanding of the interactions between government policy and the U.S. scientific and technological enterprise and to show how the concepts and analytic perspectives of political science are useful in describing and explaining those interactions. It will focus on a particular sector—the exploration and exploitation of outer space. The course will trace the evolution of U.S. space policy and of the institutions and processes through which space policy is formulated and implemented. It will identify the major issues facing the new Administration and Congress related to space policy goals for the next decade and will give you an opportunity to analyze some of those issues and to argue for particular policy options. The course will also treat some potential major space projects for the 1990s and beyond which require early investments of public resources, and you will be asked to discuss how those projects might be evaluated by current policymakers.

After a few introductory sessions, the course will be divided into three portions:

(1) Policy History of U.S. Space Activities—Apollo and Its Aftermath.

(2) Current Issues in Space Policy—Survival Crisis or the Dawn of a New Era?

(3) Our Future in Space—Marginal Activity or Key to Human Survival?

For each portion of the course, each student will prepare a 10-12 page typewritten paper in response to an assignment which will be distributed at the first class meeting of that course element. This assignment will also contain a detailed schedule of topics for class meetings and readings for that part of the course. The grade for the course will be based on these three papers and on a final examination, which will cover all the course material.

The course will be based primarily on my lectures, with your questions and class discussion strongly encouraged. I hope to schedule 3-5 guest speakers during the semester and occasionally to use a film or other visual supplement to communicate a particular point.

Reading for the course will be drawn from three different classes of materials:

(1) Books for purchase.

John M. Logsdon. *The Decision to Go to the Moon: Project Apollo and the National Interest.*

B.J. Bluth and S.R. McNeal. *Update on Space.* Vol. 1.

Charles E. Lindblom. *Policymaking Process.*

(2) Materials distributed in class without charge.

Steven Lefevre. *Technology Politics.*

Other material available free and in sufficient quantity from government agencies and/or aerospace industries.

(3) Materials available either on reserve in the library or at the cost of duplication.

II. Research Assignment: The Evolution of U.S. Space Policy

The reading assigned for this portion of the course (listed below) traces the evolution of U.S. space policy from the initial reactions to Sputnik in 1957 to the present time. Your assignment is to identify the major influences, operating through the policymaking process, which have shaped that policy. The basic question you are being asked is: "How can the politics of U.S. space policy be best understood?"

Your basis for answering this question is the material in the "supplementary analytical unit" called *Technology Politics,* which will be distributed in class. In this brief book are discussions of four alternate "policy perspectives" intended to be useful for understanding the processes through which decisions on technology-intensive issues are reached. You should use these discussions and the historical readings on space policy to prepare a paper discussing which policy perspective is most useful to you in understanding how U.S. space policy has been made. Does space policy appear to be a product of rational choice, of competition among various government agencies, of the struggle among interest groups, or of the powerful influence of business interests which dominate government policy? Are none of these policy perspectives useful? Or are several?

You can use the whole twenty-plus years of policy history as your empirical base for this paper, or you can limit yourself to specific major decisions (at least two) such as:

(1) Setting up NASA in response to Sputnik.

(2) The commitment to a manned lunar expedition as a national goal.

(3) The choice of a particular approach, lunar orbit rendezvous, to accomplish the Apollo mission.
(4) The 1969-70 decision not to undertake another Apollo-like program aimed at manned planetary exploration.
(5) The commitment to Space Shuttle development.

Assigned Readings:

John Noble Wilford. "Riding High." *Wilson Quarterly.* Autumn 1980, pp. 57-70.

John Logsdon. "Opportunities for Policy Historians: The Evolution of the U.S. Civilian Space Program." (Unpublished paper.)

John Logsdon. *The Decision to Go to the Moon.* Chap. 1-5.

John Logsdon. "Selecting the Way to the Moon." *Aerospace Historian.* June 1971, pp. 63-70.

John Logsdon. "An Apollo Perspective." *Astronautics and Aeronautics.* December 1979, pp. 112-17.

John Logsdon. "The Policy Process and Large Scale Space Efforts." *The Space Humanization Series.* Vol. 1, No. 1, 1979, pp. 65-80.

John Logsdon. "The Space Shuttle Decision: Technology and Political Choice." *Journal of Contemporary Business.* Vol. 7, No. 3, 1979, pp. 13-30.

Amitai Etzioni. *The Moon-Doggle.* See pp. vii-xv.

White House. "Fact Sheet—U.S. Civil Space Policy." October 11, 1978.

Schedule of Classes

Overview: The Evolution of U.S. Space Policy.
Apollo and Its Impacts.
Guest speaker: Michael Collins.
When Scientists Disagree: The LOR Decision.
After the Moon, Mars?
Commitment to the Shuttle.
The Current State of U.S. Space Policy.

III. Research Assignment: Current Space Policy Issues

Your assignment is to prepare a case study of a current space policy issue which discusses both: (1) the nature of the issue and the elements of controversy associated with it; and (2) the process through which that policy issue is being decided.

With respect to the latter aspect of the assignment (which should receive proportionately more attention than the former), what Charles Lindblom has to say in *The Policy-Making Process* is relevant: "To understand who or what makes policy, one must understand the characteristics of the participants [in the policy-making process], what parts or roles they play, what authority and other powers they hold, and how they deal with and control each other." In general, you should make extensive use of the Lindblom book to place your case study in the context of some more general observations about the policymaking process. That is, you should show how elements of your case are examples of some of the concepts and relationships which Lindblom discusses.

Your paper should be a descriptive analysis of an issue; you are not expected to discuss what policy the country should adopt on the issue you study. Rather, you should identify the stakes, the stakeholders, and the way in which a decision will be reached. You are welcome to speculate on the most likely outcome of the policy process you choose to study.

You should limit your paper to a *specific* space policy issue, not discuss space policymaking in general. Among issues you might select as a focus are:
(1) the future of the planetary program;
(2) attempts to obtain support for the solar power satellite concept;
(3) maintaining support for the Space Shuttle in the face of schedule slippages and cost overruns;
(4) the appropriate goals for military space activities;
(5) federal involvement in areas of space activity with commercial potential, such as space manufacturing;
(6) the U.S. position on ratification of the U.N. Moon Treaty;
(7) attempts to secure approval for a post-Shuttle major development project for NASA;
(8) organizing an operational satellite remote sensing system for the United States;
(9) the attempts to focus attention on the concept of space colonies;
(10) relating space activities to U.S. foreign policy interests vis-a-vis Europe and/or Japan;
(11) using space technology as an instrument of our foreign assistance program;
(12) proposals by Comsat General to establish a new direct broadcast television service via satellites in the United States;
(13) controversies over the use of military-derived technologies for civilian space applications; or
(14) how best to organize the U.S. government's share of the nation's civilian space effort.

This list of potential topics is far from exhaustive, and it probably would be useful for us to schedule an appointment before you get very far on your assignment.

Your source material should include Congressional hearings and reports, articles in such trade magazines as *Aviation Week and Space Technology,* general periodical articles, NASA and other executive agency reports and publications, and interviews with participants in and observers of the space policy process.

Schedule of Class Topics and Supporting Reading

(1) *The New Politics of the U.S. Space Program*
Guest Speaker: Mark Chartrand, Executive Director, National Space Institute.
Readings:
Dennis Overbye. "Time to Halt the Retreat from Space." *Discover.* March 1981.

Trudy E. Bell. "Space Activists on the Rise." *Insight.* August-September 1980.

Charles Chafer. "The Role of Public Interest Groups in Space Policy." In: *Space Manufacturing III.*

Brian O'Leary. "First Word." *Omni.* February 1981.

(2) *The Future of Space Science Programs*
Guest Speaker: James van Allen, University of Iowa.
Readings:
Richard R. Nelson. "The Simple Economics of Basic Research." In: Lefevre. *Technology Politics.*

"A New Decade of Science and Astronomy in Space." *New Scientist.* Jan. 8, 1981.

Articles by Bruce Murray and Carl Sagan. From: *The Planetary Report.* Vol. 1, No. 1.

Tony Reichhardt. "Why We Explore the Planets." *Washington Post.* Nov. 16, 1980.

Ron Konkel. "Solar System Exploration as a National Priority: An OMB Perspective." (Unpublished.)

Amitai Etzioni. *The Moon-Doggle.* See pp. 195-198.

(3) *Space Industrialization: What Are the Payoffs?*
Readings:
Charles Gould. "Large Scale Benefits of Space Industrialization." In: Bluth and McNeal.

Robert Hammel. "Materials Processing in Space." In: Bluth and McNeal.

Gene Bylinsky. "Industry's New Frontier in Space." *Fortune.* January 24, 1979.

Charles Cooper. "Shuttle." *New Yorker.* Feb. 9 and 16, 1981. (Excerpts.)

(4) *Space: A New Arena for Military Conflict?*
Readings:
Stanley Rosen. "The Role of the Military in Space." In: Bluth and McNeal.

"The New Military Race in Space." *Business Week.* June 4, 1979.

"Laser Technology Demonstration Proposed." *Aviation Week and Space Technology.* Feb. 16, 1981.

Anonymous. "The High Seas of Space." (Unpublished.)

Herbert Scoville and Kosta Tsipis. "Can Space Remain a Peaceful Environment?" Stanley Foundation Occasional Paper #18.

IV. Research Assignment: The Future of the U.S. Space Program

Decisions to be made in the next few years will determine, to a significant extent, the goals and pace of the U.S. space effort for the next decade or more. This is a situation that seems to occur approximately every ten years, at least with respect to the civilian side of the national space program. In 1961, NASA was assigned the Apollo mission; in early 1972, Space Shuttle development was approved. The question now is: What next?

Your assignment is to prepare a policy forecast of the most likely response to this "what next" question. This forecast can be prepared from *either* of two perspectives:

(1) An identification of what you believe is the appropriate next objective (or objectives) of the national space program, and an analysis of the nature and likelihood of the policy and political decisions which will be required to establish and implement that objective; or

(2) An analysis of the current and short-term future "policy climate" for space and, on the basis of that analysis, a forecast of what kinds of objectives are most likely to be selected for the national space program of the 1980s.

Whichever perspective you choose, your focus should be on the next 1-10 years, not the longer term. You should emphasize future *policy issues and actions in your forecast, not technological opportunities;* another way of stating the assignment is that you are being asked to integrate the readings and discussions of the course to construct a plausible scenario in response to the question: "What next in space *policy?*" Your paper will be evaluated primarily on your skill in constructing such a coherent and perceptive scenario.

Among the many alternative futures you may want to think about (there are many more) are:

(1) Setting another Apollo-like goal to revitalize the civilian space program;

(2) Setting a major program goal for NASA, such as permanent manned occupancy of space, but pursuing it on a nonpriority basis;

(3) Permitting the civilian space program to evolve (becoming either larger or smaller) on an incremental basis, judging each new proposal for space activity on a case-by-case basis;

(4) Recognizing that the space environment offers attractive opportunities for increasing our national security and/or that an expanded military space effort is required to counter the Soviet threat and significantly enhance the pace, visibility, and technical capabilities of the Air Force space program; or

(5) Accelerating efforts to negotiate some sort of space arms limitation agreement and attempting to increase significantly international cooperation in space activities.

Schedule of Class Topics and Supporting Reading

(1) *What Next in Space? An Overview*
Readings:
John M. Logsdon. *The Decision to Go to the Moon.* Chap. 6.

Burton Edelson. "A National Program for Geostationary Platforms." (Mimeo.)

Mose Harvey. "Preeminence in Space: Still a Critical National Issue." *Orbis.* Winter 1969.

Tom Krebs and Ernie Herrera. "The Capability to Control Space—A New Space Doctrine." (Mimeo.)

(2) *Two Ideas That Failed (So Far): Space Colonies and Solar Power Satellites*
Readings:
G.M. Hanley. "Space Shuttle and Solar Power Satellite Systems." In: Bluth and McNeal.

Peter Glaser. "Press Briefing on SPS." December 3, 1980.

Gerard O'Neill. "High Frontier." *Astronautics and Aeronautics.* May 1978.

Gerard O'Neill. "Islands in Space." From: *The High Frontier.*

(3) *Permanent Manned Occupancy of Space: The Logical Next Goal?*
Readings:
George V. Butler. "Space Stations, 1959-?" In: Bluth and McNeal.

Clark Covington and Robert Piland. "Space Operations Center: Next Goal for Manned Space Flight?" *Astronautics and Aeronautics.* September 1980.

(4) *The Prospects for Private Enterprise in Space*
Guest Speaker: Charles Chafer, Space Services, Inc.
Reading:
Klaus Heiss. "New Economic Structures for Space for the Eighties." *Astronautics and Aeronautics.* January 1981.

(5) *The Long-Term Prospects*
Reading:
Krafft Ehricke. "The Extraterrestrial Imperative." In: Bluth and McNeal.

A Course on Space Policy and the Course Syllabus

Nathan Goldman
Government Department
The University of Texas, Austin

I. The Course

After teaching at the University of Texas for a year, I received permission to offer the "Space Politics" course in the full semester format. (A previous version of the course at Johns Hopkins University ran one month.) Texas law requires that all 46,000 students take two semesters of American Government in order to graduate. The first semester examines the structures and institutions of state and national government. The second semester is a topics course which applies first semester knowledge to one specific policy area; I offer "Politics of U.S. Space Exploration" as such a course. Naturally, the syllabus is simplified to accommodate the demands of an introductory course.

The course enrolls approximately three hundred students from engineering, sciences, and liberal arts. The class meets twice a week for lectures supplemented by a few NASA films. During the third meeting period, the class is divided into ten discussion groups (thirty students each) led by two graduate students.

Grades are based on a midsemester exam (40 percent), a final exam (50 percent), and graduate student evaluations (10 percent) based on participation and oral reports on readings.

Readings for the course include four books and a packet of articles. Blaine's *End of an Era in Space Exploration* provides the class with a useful though technical history of spaceflight through the late 1970s.

T.A. Heppenheimer's book, *Toward Distant Suns,* speculates about the future and is enjoyable reading for the students. Logsdon's *The Decision to Go to the Moon* provides a political analysis of the race to the Moon, which atunes the students to the political counterpoint inherent in all governmental decisions. The packet of articles and the first volume of the *Space Humanization Series* (published by the Institute for the Social Science Study of Space) illustrate various social science concepts which are discussed in the lectures.

The space issue represents a flexible device for studying domestic and foreign politics. Initially, lectures portray the history of spaceflight, noting pre-World War II efforts by the Greeks (Icarus), the Chinese, and the Indians. The next segment of the course analyzes the U.S. space program since the National Advisory Committee on Aeronautics (NACA). Lectures examine NASA as a bureaucracy and its administrative decisionmaking. Organization and systems analysis provide the framework for discussing NASA within its environment, which includes not only the other agencies (such as the Department of Defense and the Office of Management and Budget), but also the President, the Executive Branch, the Congress, the aerospace industry, space interest groups, and the general public.

Law serves as the transition between the domestic and the international policy arenas. Here, the lectures stress the importance of space law in the creation and maintenance of an international order in space. In addition to describing the duties and obligations of nations in space, space law also defines property rights in space and establishes a basis for the development of space by private individuals, corporations, and governments.

After discussions of this legal superstructure, the course comparatively analyzes the resources, projects, and goals of other space powers, such as the Soviet Union, Japan, India, China, and the European Space Agency. The course then probes the opportunities for international cooperation and conflict in space, for example, balance of power and war in space. Similarly, course participants discuss the effects of energy via satellite on the Third World and on the distribution of political power.

The final class sessions consider the future of humanity. In this section, space applications and trends are projected through and beyond the end of the century. With the expansion of satellite technology and applications, private capital and enterprise may become integral ingredients in international operations in space. Large space structures, space stations, and orbital tugs might constitute the skeleton, but the heart of future space operations has to be the industrialization of space, i.e., satellite applications, metallurgy, pharmaceuticals, energy, and resources from space. Finally, we speculate about mining operations on the Moon and the asteroids, the colonization of space—and on, beyond the horizon of time.

Purposes and Goals of the Course

(1) The course gives students insights into the functioning of politics. Because the course addresses topics of interest to science and engineering students, such students are more likely to retain an understanding of American government.

(2) The course facilitates the cross-fertilization of ideas. Several graduate students in other disciplines and at least one professor (aerospace engineering) have attended the classes. Moreover, a handful of juniors and seniors usually take the course as an independent study and write separate research papers on space law and politics. In this course, insight flows from professor to students and vice versa.

(3) The course helps students make informed choices about the space program, as well as other policy questions. At San Jose State University's Careers in Space Symposium, an engineer declared that funding cuts in his field must be the product of black magic. I stressed that such cuts are just the result of politics—although, in practice, the two may appear to be synonymous. In that context, my students may be "the Sorcerer's Apprentices."

II. Syllabus

University of Texas, Austin
Course: Politics and Outer Space
Instructor: Nathan Goldman

(1) History of Spaceflight

A. U.S.

Readings: J.C.D. Blaine. *The End of an Era in Space Exploration.* American Astronautical Society, 1976, Introduction and pp. 1-8, 33-127.

L. Mandelbaum. "Apollo: How the U.S. Planned to Go to the Moon." *Science.* Vol. 163, 1969, p. 649.

Recommended: John M. Logsdon. *The Decision to Go to the Moon.* University of Chicago Press, 1970.

B.C. Harker. "The Idea of Rendezvous: From Space Station to Orbital Operations, 1895-1951." *Technology and Culture.* Vol. 15, 1974, p. 373.

E.M. Emme. "Early History of the Space Age." *Aerospace History.* Vol. 13, 1966, p. 74.

B. Soviet Union

Readings: Blaine. See pp. 8-30, 133-36.

(2) NASA

Readings: Richard Hirsch and Joseph J. Trento. *The National Aeronautics and Space Administration.* N.Y.: Praeger, 1973, pp. 40-84, 134-48, 164-75.

T.P. Murphy. "Congressional Liaison: The NASA Case." *Western Political Quarterly.* Vol. 25, 1972, p. 192.

Recommended: P.R. Schulman. "Nonincremental Policy Making: Notes Toward an Alternative Paradigm." *American Political Science Review.* Vol. 69, 1975, p. 1354.

G.S. Robinson. "NASA's Bilateral and Multilateral Agreements—A Comprehensive Program for International Cooperation in Space Research." *Journal of Air Law.* Vol. 36, 1970, p. 729.

(3) NASA and Its Environment

Reading: Hirsch. See pp. 126-33, 206-207.

A. NASA and Public

Readings: D.M. Michael. "The Beginning of the Space Age and American Public Opinion." *Public Opinion Quarterly.* Vol. 24, 1960, p. 573.

Herbert E. Krugman. "Public Attitudes Toward the Apollo Space Program, 1965-75." *Journal of Commerce.* Vol. 27, 1977, p. 87.

Recommended: G.A. Almond. "Public Opinion and the Development of Space Technology, 1957-60." *Public Opinion Quarterly.* Winter 1960, p. 553.

B. NASA and Universities

Reading: W.H. Lambright and L.L. Henry. "Using Universities: The NASA Experience." *Public Policy.* Vol. 20, 1972, p. 61.

Recommended: T.W. Adams and T.P. Murphy. "NASA's University Research Programs: Dilemmas and Problems on the Government-Academic Interface." *Public Administration Review.* Vol. 27, March 1967, p. 10.

C. NASA and Congress

Readings: J.R. Kerr. "Congress and Space: Overview or Oversight?" *Public Administration Review.* Vol. 25, Sept. 1965, p. 185.

T.P. Jahrige. "The Congressional Committee System and the Oversight Process: Congress and NASA." *Western Political Quarterly.* Vol. 21, 1968, p. 227.

(4) U.S. Law and Space

Readings: G.D. O'Brien. "Problems Introduced by the National Aeronautics and Space Act of 1958." *Hastings Law Journal.* Vol. 11, 1960, p. 285.

G.D. O'Brien. "Patent Provisions of the NASA of 1958." *Journal of the Patent Office Society.* Vol. 41, Sept. 1959, p. 651.

Recommended: S.I. Doctors. "Transfer of Space Technology to the American Consumer: The Effect of NASA's Patent Policy." *Minnesota Law Review.* Vol. 52, March 1968, p. 789.

(5) Space Law

Readings: P.C. Jessup and H.J. Taubenfeld. "U.N. Ad Hoc Committee on the Peaceful Uses of Outer Space." *American Journal of International Law.* Vol. 53, October 1959, p. 877.

D.M. Arons and P.G. Dembling. "Evolution of the Outer Space Treaty." *Journal of Air Law.* Vol. 33, Summer 1967, p. 419.

R.C. Hall. "Rescue and Return of Astronauts on Earth and in Outer Space." *American Journal of International Law.* Vol. 63, 1969, p. 197.

R.C. Hall. "Space Law—International Liability for Space Exploration Activities." *Texas International Law Journal.* Vol. 7, 1972, p. 523.

A. Gorbiel. "Legal Status of Geostationary Orbits: Some Remarks." *Journal of Space Law.* Vol. 6, 1978, p. 171.

Recommended: S. Bhatt. "The United Nations Space Treaty and the Freedom of Outer Space." *Indian Political Science Review.* Vol. 2, 1968, p. 132.

S. Bhatt. "Cosmos 954 and the Law of Outer Space Objects." *Journal of Space Law.* Vol. 6, 1978, p. 107.

R.E. Hansen. "Freedom of Passage on the High Seas of Space." *Strategic Review.* Vol. 5, 1977, p. 84.

S. Gorove. "Criminal Jurisdiction in Outer Space." *International Law.* 1972, p. 313.

(6) International Relations/Comparative

Readings: F.X. Kane. "Space Age Geopolitics." *Orbis.* Vol. 14, 1971, p. 911.

R. Jastrow and H.E. Newell. "The Space Program and the National Interest." *Foreign Affairs.* Vol. 5, 1972, p. 532.

S. Bhatt. "Some Perspectives on Outer Space Exploration by India." *Indian Quarterly.* Vol. 32, 1976, p. 18.

R.F. von Preuschen. "European Space Agency." *International and Constitutional Law Quarterly.* Vol. 27, 1978, p.46.

Recommended: L. Sedov. "International Cooperation in Space Exploration." *Indian Quarterly.* Vol. 32, 1976, p. 18.

L. Sedov. "Chinese 'Secrets' Orbiting the Earth." *Spaceflight.* October 1977, pp. 355-61.

L. Sedov. "Japan Expands Technology Program." *Aviation Week and Space Technology.* October 1977, pp. 104-108.

(7) Balance of Power/War

Readings: G.D. Schrader. "Defense in Outer Space." *Military Law Review.* Vol. 49, 1970, p. 157.

R.J. Zedalis and C.L. Wade. "Anti-Satellite Weapons and the Outer Space Treaty of 1967." *California Western International Law Journal.* Vol. 8, Summer 1978, p. 454.

Recommended: N. Brown. "Reconnaissance from Space." *World Today.* Vol. 27, 1971, p. 68.

L. Freedman. "The Soviet Union and Anti-Space Defense." *Survival.* Vol. 19, 1977, p. 16.

L. Freedman. "War's 4th Dimension." *Newsweek.* November 29, 1976, p. 46.

(8) Space Applications

Readings: J.E.S. Fawcett. "Outer Space Benefits." *International Behavioral Scientist.* Vol. 5, 1973, p. 57.

S.A. Levy. "Intelsat: Technology, Politics and the Transformation of a Regime." *International Organization.* Vol. 29, 1975, p. 655.

H. DeSausser. "Remote Sensing by Satellite: What Future for an International Regime." *American Journal of International Law.* Vol. 71, October 1977, p. 707.

Recommended: R.R. Colino. "Intelsat: Doing Business in Outer Space." *Journal of Transnational Law.* Vol. 6, 1967, p. 17.

L.R. Caruso. "International Cooperation in the Production of Solar Energy Through the Use of Satellites." *Lawyer of the Americas.* Vol. 9, February 1977, p. 540.

L.R. Caruso. "Mining in Space." *Science Digest.* October 1977, p. 35.

(9) The Future

Readings: J.P. Vajk. "The Impact of Space Colonization on World Dynamics." *Technological Forecasting and Social Change.* Vol. 9, 1976, p. 361.

J.H. Glazer. "Domicile and Industry in Outer Space." *Columbia Journal of Transnational Law.* Vol. 17, 1978, p. 67.

Recommended: Gerard O'Neill. *The High Frontier.* Bantam Books, 1978.

Gerard O'Neill. "Space Stations and Habitats: A Workshop." *American Society for International Law Proceedings.* Vol. 72, 1978, p. 268.

M. Maruyama. "Social and Political Interactions Among Extraterrestrial Human Communities: Contrasting Models." *Technological Forecasting and Social Change.* Vol. 9, 1976, p. 349.

Jerome Clayton Glenn and George S. Robinson. *Space Trek.* Warner Books, 1980.

Experiences of Five Years of Teaching Space Policy and a Sample Course Syllabus

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I. Teaching Experiences

Five years ago I began teaching courses on space policy under the guise of general political science courses (such as international problems or a political science seminar). Now courses including space policy analysis are openly labeled in the course catalogue, although formal designation of a space policy course will require review and approval by the department, the curriculum committee, and the faculty senate.

The current course on space policy is a seniors' seminar for social science students that averages an enrollment between ten and thirty. The course presupposes inadequate technological preparation, but a capacity for independent work. The course is structured as an intensive and extensive survey, including lectures, movies, student book reports, telelectures, and field trips.

Course Materials

Bibliographical sources include *The Directory of Aviation and Space Education* (published by the American Society for Aerospace Education), which is among the best available materials. This document includes sections on relevant audiovisuals, books, periodicals, publications, career materials, and organizations.

Three government publications are required reading and provide the factual basis for subsequent policy analyses. These documents can be obtained free of charge.

(1) *The Aeronautics and Space Report of the President* is compiled annually by NASA and constitutes the only report that reviews pertinent activities of most government agencies (such as NASA, Defense, NOAA, Interior, Energy, and Transportation). This is an excellent manual whose only shortcoming is a natural reticence to discuss classified programs.

(2) *The NASA Program Plan* projects future NASA activities and probably is the best planning document produced by any government agency. However, the *Plan* does represent more of a "wish list" than actual Administration funding priorities.

(3) *The Congressional Research Service Issue Briefs* supply the Congressional perspective on space policy. Three briefs are maintained and regularly updated: (a) Space Policy and NASA Funding, (b) Solar Energy from Space Satellite Power Stations, and (c) Space Shuttle.

Three books are required reading for all students. The book package varies every semester in order to take advantage of new publications. After some experimentation, the current book package covers the civilian and the military space programs and space policy formulation:

(1) A number of books deal with the present civilian space program, its potential impact on society, and mankind's future in space. Ben Bova's *The High Road* is an excellent primer on the subject. Other possible texts include: *Update on Space* by Bluth and McNeal, *Doomsday Has Been Cancelled* by J. Peter Vajk, and *Enterprise* by Jerry Grey. The classic *History of Rocketry and Space Travel* by Ordway and von Braun is a useful reference book.

(2) Very few lay books address the military space program. *Confrontation in Space* by G. Harry Stine is probably a seminal book. My supplements include *Readings* from the Space Course of the National War College and the *Military Space Doctrine Symposium* of the U.S. Air Force Academy.

(3) Space policy formulation is a comparatively new field in political science; texts are rare. *The Decision to Go to the Moon* by John Logsdon is useful but somewhat dated. *Between Sputnik and the Shuttle* of the AAS History Series is also insightful, particularly if used in conjunction with supplementary readings from *Towards the Endless Frontier* by the House Committee on Science and Technology.

As part of the course assignment, each student is required to write a book report and then make a class presentation. These books are placed on reserve in the library, and each student is responsible for a different book. The selection of books encompasses the entire spectrum of the space program.

I try to show one or more movies in each class. The Department of Defense, the National Oceanic and Atmospheric Administration, NASA, and Comsat all offer the loan of useful films. Additional sources include the *Cosmos* series by Carl Sagan and corporate films. Instructors should be aware that corporate movies are instructive, but occasionally overly hawkish for a political science audience.

Telelectures have been an interesting and useful teaching tool in a number of classes. This method is particularly suitable for a course on space policy, probably because of the subliminal effect of using "high technology." I have found that very busy individuals in the space community usually take a few minutes to talk to my class by telephone, perhaps because space policy is a new field.

Although at first glance West Virginia hardly seems the place to find aerospace activities worthy of a field trip, two options have been available to classes: the Comsat Earth Station at Etam and the National Astronomical Observatory at Greenbank.

The coordination of the various factors described above requires a great deal of curriculum flexibility, particularly because of the varying movie availability and arrival, which rarely coincide with the movies' logical place in the sequence of the course. The same constraint holds true for the availability of guests for the telelectures and their topics of discussion. My usual warning to the class is that the syllabus describes the scope but not the sequence of the course.

The development of this course on space policy has proceeded for the most part on a trial and error basis. This new area of policy studies will require a standard variety of publications comparable to those available in other fields. Above all, space policy will require a survey textbook, accompanied by the usual student handbook, instructors' manual, and a well-integrated package of audiovisual accessories.

II. Syllabus

Fairmont State College
Course: Outer Space Policy
Instructor: Michael Fulda

Introduction

The maiden flight of the Space Shuttle has ushered in a new era by giving mankind routine access to a new environment. The Shuttle will be as significant in the development of space as the sailing ship was in the development of the seas. The use of space resources will spearhead the third industrial revolution. But the growth rate of this capital-intensive industry depends to a large extent on public policy. Now, more than ever, the road to the stars begins in Washington.

This course consists of three parts. The first part deals with the past, present, and future of humans in the new space environment. This part will be covered mainly by films, book reports, class discussions, and—possibly—field trips. The second and third parts deal with the formulation of outlooks for space policy. These parts will be covered by government materials, lectures, and telephone conferences.

Requirements

This is an intensive multimedia course. Regular class attendance is strongly encouraged. There will be one monthly assignment and a final examination. The four assignments will each consist of a book review. The first three book reviews will be on the required texts, the other one from the list of recommended texts.

Required Texts

Ben Bova. *The High Road.* 1981.
Frederick C. Durant. *Between Sputnik and the Shuttle.* AAS History Series, Vol. 3, 1981.
G. Harry Stine. *Confrontation in Space.* 1981.
Aeronautics and Space Report of the President, 1980 Activities.
NASA Program Plan, 1981-1985.
Congressional Research Service Issue Brief:
Space Policy and NASA Funding.
Solar Energy from Space—Satellite Power Stations.
Space Shuttle.

Recommended Texts

Adelman and Adelman. *Bound for the Stars.*
AIAA. *Proceedings of the Twenty-Third Colloquium on the Law of Outer Space.*
William Bainbridge. *The Space Flight Revolution.*
B.J. Bluth & S.R. McNeal. *Update on Space.*
M. Fulda. *Selected space articles.*
"Social mood and space effort."
"Face in space: the personalization of planetary exploration."
Anderson campaign space constituency portfolio.
"The political organization of the space constituency."
"The outer space constituency during the 1980 campaign."
Jerry Grey. *Enterprise.* 1980.
T.A. Heppenheimer. *Toward Distant Suns.*
I.S.S.S.S. *The Space Humanization Series.*
J. Logsdon. *The Decision to Go to the Moon.*
N. Mailer. *Of a Fire on the Moon.*
H.E. Newell. *Beyond the Atmosphere.*

J.E. Oberg. *Red Star in Orbit.*
B. O'Leary. *The Fertile Stars.*
G. O'Neill. *The High Frontier.*
C. Sheffield. *Earth Watch.*
D.D. Smith. *Space Stations: International Law and Policy.*
U.S. Air Force Academy. *Military Space Doctrine Symposium.*
U.S. House of Representatives. *Towards the Endless Frontier.*
U.S. Government. *United States & Soviet Progress in Space.*
J.P. Vajk. *Doomsday Has Been Cancelled.* 1979.
Aaron Wildavski. *The Politics of the Budgetary Process.* 1979.

Telelectures

A number of telephone conversations by means of the telelecture set will be held with private and public officials. It is hoped and expected that the class will ask intelligent questions of the guest lecturers.

Field Trips

Two class outings are planned, travel budget and logistics allowing. One is the Comsat Earth Station at Etam, in Preston County. This station has the highest traffic volume within the Intelsat system. The other is the Greenbank National Observatory in Pocahontas County.

Films

The first part of each class period shall be devoted to the viewing and discussion of space films. About fifty films shall be viewed during the course. These are provided by the National Aeronautics and Space Administration, the Department of Defense, the National Oceanic and Atmospheric Administration, the Communications Satellite Corporation, and the Thiokol Corporation. We shall also view some episodes of the *Cosmos* series and the L-5 Society slide show.

Course Content

Part 1: The New Environment

The Past

The V-2. "We aimed for the stars"
Sputnik. "I am Eagle"
Apollo. "A small step for man, a giant leap for mankind"

The Present

Communications
- Operational Space Systems
  - Intelsat, Marisat
  - Domestic, Commercial, and Military Communication Satellites
  - Military Navigation Satellites
- Space Communication Experiments
  - Experimental Satellites
  - Communications Research
  - Direct Broadcast Satellites

Earth's Resources
- Inventorying and Monitoring
  - Earth Resources: Renewable and Non-Renewable Resources, Geodynamics
  - Sea Resources
- Environmental Analysis and Protection
  - Weather, Research, and Satellite Operations
  - Atmospheric and Magnetospheric Research

Space Science
- Studies of Sun, Earth, the Planets, the Universe, the Life Sciences

Transportation
- Space Transportation System: Space Shuttle, Spacelab, Upper Stages, Expendable Launch Vehicles

Space Energy
- Energy for Use in Space and on Earth

Space Materials
- Materials Processing in Space

The Future

NASA
- Space Station, Moon Station, Space Colony
- Self-Replicating Robots in Our Solar System

DoD
- Global Surveillance
- The Big C3 (Command, Control, Communications)
- Buck Rogers Is Here (Laser Battle Stations)

NOAA
- Doing Something about the Weather
- How to Count Whales

Private Enterprise
- ConEd and Hilton in the Sky
- The Space U-Haul
- The Mining of Zero Gravity
- Asteroids: How to Retail One Cubic Mile of Nickel

Part 2: Space Policy Formulation

The Law
- International Space Agreements
- National Space & Aeronautics Act
- The Moon Treaty
- Strategic Arms Limitation Talks

The Government
- The President
  - Office of the Science Adviser
  - Office of Management and Budget
- The Congress
  - House Authorization and Appropriations Committees
  - Senate Authorization and Appropriations Committees
  - Office of Technology Assessment
  - General Accounting Office
- The Executive Departments and Agencies
  - NASA, NOAA, DoD, DOE, NSF, Interior

The Interest Groups
- Aerospace Corporations
- Space End-User Corporations
- Labor Unions
- Professional and Trade Associations
- Research Institutes
- Universities and Educators
- Citizen Public Interest Groups
- Science Fiction Groups

The Public
- "The greatest event since creation"
- Space, Foreign Aid, and Welfare Chests
- The National Air and Space Museum
- The Star Trek Movement

Part 3: Space Policy Outlook

Space Race:	The Russians *and* Europe *and* Japan
Space Station:	The Shuttle Must Go Somewhere
Space Symbiosis:	The Military/Civilian Affair
Space Business:	Texas Wildcat Money in the Sky
Space Science:	The Universe Can Wait
Space Politics:	Citizens Who Will Not Wait

Psychology

Utilization of Orbital Human Factors in College Teaching

T. Stephen Cheston
Georgetown University

Orbital human factors can serve as a useful heuristic device in the teaching of psychology, especially behavioral, social, environmental, and industrial psychology. The inherently exotic quality of topics related to outer space naturally attracts the interests of students. Students often will dedicate themselves to studying and researching space-related subjects with greater-than-usual intensity.

While Shuttle/Spacelab topics are of great interest, students gravitate more toward issues relevant to the permanent occupancy of space (which include Shuttle/Spacelab program topics, but also encompass a wider range of social questions).

Orbital human factors study is most productive in courses designed for students who have moved beyond introductory psychology courses. Orbital human factors represents a means of applying basic knowledge in the psychological sciences and, furthermore, provides opportunities for developing research projects based on well-defined behavioral data.

The topics listed below concentrate on the permanent occupancy of space and serve as potential case studies for various aspects of the psychological sciences. During the 1980s, the Shuttle/Spacelab program will be a continual source of new empirical data that can be utilized by faculty to teach the psychological aspects of the permanent occupancy of space.

The orbital human factors issues pertinent to the next century are more general and are listed separately.

Topics for the Permanent Occupancy of Space (1980s and 1990s)

(A) Selection
- (1) Testing devices to determine
  - (a) technical skills
  - (b) psychological adaptation to environment, social group, and stress
- (2) Methods to acquire perceptive psychological case histories of applicants
- (3) Methods to determine optimum time in orbit
- (4) Factors to consider: specific job function, personality type, level of education, age, sex of individual and the male-female distribution in the space facility, prior psychological history, family relationships, and motivation for being in space
- (5) Utilization of computers in the selection process

(B) Training
- (1) Utilization of simulators in the training process for
  - (a) acquisition and adaptation of necessary work skills for service in orbit
  - (b) adaptation to the space environment, social group, and stress
- (2) Utilization of computers in skill acquisition and adaptation to space service
- (3) Unit training vs. individual training—during training, development of task teams that require the whole group to be replaced if one member of the team cannot perform—analogy can be found in certain heavy weapons military crews
- (4) Training for crew integration with ground control

(C) Procedures for personnel in orbit

General problem—space facilities will be institutions where work, leisure, and all extra work activity will occur in one location for sustained periods of time. The procedures at such facilities should be designed to meet the conscious and subconscious needs of the resident personnel to help ensure the physical safety of the facility and maximum personnel productivity. Procedures should address questions such as governance, mental health, social and cultural environment, financial issues, communications, civil and criminal codes.

Specific topics:

- (1) Systems to divide authority between on-board personnel and ground control that are used in the U.S. space program vs. the Soviet space program
- (2) Appointed leadership vs. real leadership and methods to converge the two at a space facility
- (3) Methods to inform the leadership of crew sentiment—e.g., town meetings to air problems
- (4) Minimization of mindless automated behavior
- (5) Utilization of simulators in orbit for skill maintenance and upgrading
- (6) Procedures to handle disruptive activities both on the individual level (e.g., criminal behavior) and on the group level (strikes)
- (7) Methods for early detection of performance degradation
- (8) Establishment of viable norms for balancing individual autonomy against need for central control—includes the right to individual privacy vs. right of administration to monitor the physical and mental health of personnel and the right of social science researchers to collect data on personnel
- (9) Establishment of balance between work and leisure—avoiding excessive work on the one hand and excessive inactivity on the other
- (10) Provisions for privacy and avoidance of overexposure to companions
- (11) Establishment of levels of permissible physical risk for various categories of personnel
- (12) Development of criteria for the utilization of pharmaceuticals to reinforce behavior or handle crisis management—includes the utilization of alcohol and caffeine
- (13) Establishment of legal protocols adapted to the psychological situation at space facilities—involves both the criminal and civil codes and should take into account multinational work forces
- (14) Procedures to handle missions with less than optimum health conditions
- (15) Means for individual communication with family and friends on Earth—e.g., channels exempt from administrative monitoring
- (16) Policies to deal with religious and cultural ceremonies and rituals—e.g., Christmas
- (17) Procedures to address philosophic issues—experience indicates that residency in orbit tends to make individuals more reflective about philosophic questions such as the meaning of existence and humanity's relationship with the cosmos
- (18) Methods to compensate personnel who maximize productivity—e.g., salary, profit-sharing, stock options

Topics for the Twenty-First Century

- (1) Comparison between contemporary communities established for economic purposes in hostile physical environments (e.g., Spitzbergen Island) and possible company towns in space
- (2) Strikes at space industrial operations and their psychological and economic implications
- (3) Changes in consciousness caused by the different visual experiences of long-time residence in space (e.g., the constant sight of the entire Earth against a background of black emptiness)
- (4) Optimum designs for space facilities to reduce claustrophobic feelings and increase feelings of well-being
- (5) Problems occasioned by space workers developing skills that are usable only in space and not transferable to Earth-based industries (analogous to seamen and miners)
- (6) Optimum population sizes and densities of space communities to meet medical, educational, and cultural needs and to maintain individual psychological well-being
- (7) Long-term socio-psychological changes caused by sustained separation from Earth society
- (8) The psychological impact of long-term separation from the 24-hour day/night cycle; behavior modification induced by sustained disruption of the circadian rhythm in human biology; impacts on sleep, body temperature, blood pressure

Description and Evaluation of an Undergraduate Course in Space Development

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I. Course Description

An application of a "systems approach"[1] was employed to design and teach a space development course. The course built on the interacting and interdependent innovation resources found in industry, government, and academia.[2] Space Development (taught for the first time in 1977) was stimulated by O'Neill's thinking, manifested in his undergraduate physics course at Princeton University.[3]

Course Design

The systems approach applied in this course has been termed a "metaperspective for curriculum development."[4] A "metaperspective," or "perspective on perspectives," incorporates: (1) a recognition of the essential multidimensionality of one's topic, (2) acknowledgment of the fact that those dimensions interact dynamically, and (3) the development of models that attempt to understand the dynamic interactions and utilize them in creative ways.

Course Goals and Objectives

Within the relevant liberal arts context, the following course objectives were adopted:

(1) To develop a theoretical framework for systematic consideration of the issues.
(2) To establish a historical context for present and future space development.
(3) To develop a base in state-of-the-art social science techniques that facilitates the analysis of space issues.
(4) To assess the interface of value issues and technological developments.
(5) To develop student skills in interdisciplinary thinking.
(6) To introduce students to professionals in industry, government, and academia working on space development issues.
(7) To encourage students to seek critical evaluation of their research through publication.

Extensive bibliographies supported each element in the following course outline.

Outline of Course Content

(1) Course overview: a systems approach to space development
(2) Historical background of rocket propulsion and manned space travel
(3) General systems theory
- (A) Isomorphism among systems
- (B) Mutually interdependent variables
- (C) Information exchange
- (D) Feedback
  - (1) Positive feedback (difference-amplifying)
  - (2) Negative feedback (equilibrium-seeking)
- (E) Entropy vs. evolution
- (F) Equifinality and multifinality

(4) Our neighborhood—the solar system
- (A) Other planets
- (B) Other places
  - (1) Geosynchronous orbit
  - (2) Radiation belts, asteroid belts
  - (3) Libration points

(5) Space utilization
- (A) Humans in space—the fourth environment
  - (1) Skylab
  - (2) Space Transportation System (Shuttle, Spacelab, Space Operations Center)
  - (3) Humans in the loop
    - (a) Human factors psychology ("engineering psychology")
      - (i) Human performance
      - (ii) Human learning and memory for verbal tasks and motor tasks
    - (b) Simulation
      - (i) Microprocessors and human-machine interfacing
      - (ii) Cognitive psychophysiology
  - (4) Social-ecological systems
    - (a) Community and environmental psychology
    - (b) Development and production
      - (i) Designing for health
      - (ii) Accident prevention
      - (iii) Space medicine
  - (5) Time
    - (a) Leisure and recreation
    - (b) Circadian rhythms
    - (c) Time perception
- (B) Space industrialization and manufacturing
  - (1) Resources
    - (a) Microgravity
    - (b) Vacuum
    - (c) Temperature range
    - (d) Geosynchronous orbiting
    - (e) Microbiotic isolation
  - (2) Uses
    - (a) Basic and applied research
    - (b) Development and production
    - (c) Examples (four from many are listed below)
      - (i) Electrophoretic separation
      - (ii) Crystal growth
      - (iii) Forming of molten metals
      - (iv) Solar power satellite technology development
  - (3) Applications
    - (a) Goods
    - (b) Services
    - (c) Energy

(6) Migration into space
- (A) Factors producing, reducing, or reversing effects of isolation from homeland (analogs from past migrations on Earth, e.g., Scandinavian-American migrations, 1825-1920)
- (B) Conflict
  - (1) Sources
  - (2) Reduction
  - (3) Prevention
- (C) Primary stressors and responses to them
- (D) "Push" vs. "pull" factors in migration
- (E) Identity issues

(7) Value questions and international space law
- (A) Policy and program evaluation
  - (1) Risk/benefit analysis
  - (2) Public sector and private sector interests
  - (3) National and international perspectives
  - (4) Priorities among program objectives
  - (5) Social change
- (B) Aesthetic issues
- (C) Integration of human Earth and space needs with technological goals
- (D) International relations and cooperation

(8) Higher education's present and future role in space development
- (A) As an Earth-based support system
- (B) As a space-based facilitator of adaptation by humans in a new alternative setting

(9) Designing attractive alternative human futures through space development
- (A) Space development scenarios
- (B) Design of human communities in space

II. Course Impact

(A) Students

In 1981, a survey questionnaire was sent to those students who had taken the course during the previous five years. The survey indicated a rich diversity in the course's impact on students.

One student successfully submitted his research paper, "Solar Power Satellite Issues: The Need to Look Ahead," to the DOE/NASA 1980 Satellite Power System Review and Symposium.[5] A thorough recounting of the impact of the course on that student and a descriptive summary of other students' experiences were included in a paper at the XXXII Congress of the International Astronautical Federation.[6]

Several student reports were adapted for presentation at regional conferences, including the 1981 Region V Student Conference of the American Institute of Aeronautics and Astronautics. For other students, the course strengthened long-standing space development interests which had their origins in the U.S. space program and, in some cases, early work in model rocketry. Many students developed skills that can be applied to constructing interfaces between other disciplines and space development. Still other students developed new career directions, using opportunities such as the Lunar and Planetary Institute Summer Internship.

(B) Instructor

Developing and teaching the course stimulated my thinking, research, and teaching productivity.[7] Opportunities for grant support have developed, culminating most recently in a three-year grant from the U.S. Public Health Service for research in another area of human systems.

Associate Membership in the American Institute of Aeronautics and Astronautics has been useful in contacting networks of professionals in government, industry, and academia who also are designing approaches to space education. Moreover, those networks have expanded to include persons in numerous other space-related organizations, both domestic and international. Working with individuals and groups involved in space development and related fields and acting as consultant to other interested individuals represents one of the most direct and stimulating results of the course.

Footnotes

1. C. West Churchman. *The Design of Inquiring Systems.* New York: Basic Books, 1971.

2. Howard I. Thorsheim. "Social Studies of Space Utilization and the Liberal Arts." Presented at the Fourth Princeton Conference on Space Manufacturing, Princeton University, May 14, 1979.
Also: Howard I. Thorsheim. "Alternative Curriculum Futures and General Systems Theory." *Proceedings of the 25th Annual North American Meetings of the Society for General Systems Research.* Washington, D.C., 1981, pp. 597-604.
Also: Howard I. Thorsheim and Kevin K. Dybdal. "Impact of Space Development on Educational Motivation." Presented at the XXXII Congress of the International Astronautical Federation, Rome, Italy, September 1981. Also in press: L. Napolitano (ed). *Earth Applications of Space Technology.* Pergamon Press, 1982.

3. G.K. O'Neill. *The High Frontier.* Morrow and Company, 1977.

4. Howard I. Thorsheim, Raymond Denning, and Peder Bolstad. "Metaperspectives in Post-Secondary Education." Presented at the First Meeting, Education Section, World Future Society, University of Houston, 1978.

5. Kevin K. Dybdal. "Solar Power Satellite Issues: The Need To Look Ahead." *Final Proceedings of the Solar Power Satellite Program Review.* Lincoln, Nebraska, April 22-25, 1980.

6. Howard I. Thorsheim and Kevin K. Dybdal. "Impact of Space Development on Educational Motivation." See footnote 2.

7. Howard I. Thorsheim. "Alternative Curriculum Futures and General Systems Theory." *Proceedings of the 25th Annual North American Meetings of the Society for General Systems Research.* Washington, D.C., 1981, pp. 597-604.
Also: Howard I. Thorsheim and Bruce B. Roberts. "Social Ecology and Human Development: A Systems Approach for the Design of Human Communities in Space." *Proceedings of the Fifth Princeton/American Institute of Aeronautics and Astronautics/Space Studies Institute Conference on Space Manufacturing.* Princeton, New Jersey, May 1981.

Sociology

Teaching Strategies, Select Bibliography, and Course Description and Syllabus

B.J. Bluth
Sociology Department
California State University, Northridge

I. Teaching Strategies

Teaching experience from two courses is reviewed briefly below.

(A) Update on Space Program. Since 1978, the Update on Space Program has been conducted each summer at California State University, Northridge. This program has three elements—speakers, a semester project, and readings (each discussed below). Additional materials on the program are included in the course description and syllabus.

(1) Speakers. Many people do not really believe that our society will move into space to live and work during their lifetimes, let alone in the near future; space development often appears to be a spectacular fantasy. To provide an understanding of real possibilities, options, and time frames, various speakers actually working on space projects are invited to brief the program participants. Each speaker assumes a position of responsibility in the program and presents material to an audience of intelligent novices. Speaker topics include technology, hardware, military applications, research, social and psychological issues, energy, benefits of space operations, communications and information satellites, remote sensing satellites, space stations, lunar habitation and mining, space and the evolution of the species, asteroidal mining, and education and public participation.

(2) Semester project. Each graded participant writes a term paper on some aspect of space from the point of view of human behavior systems. Topics have encompassed areas such as: stress vs. isolation in space stations; mixed crews; selection procedures used in the U.S. space program; work team effectiveness in space; leisure in lunar colonies; designing a recreation program for space colonists; education in space; changes in consciousness in space; minimizing role conflict; search for the ideal work structure; the community as a paradigm for space colonies; isolation and confinement considerations for space; satellite solar power stations and public concern; expanding our limits; shifts in legal requirements for space; the Moon Treaty; effects of crowding in residential areas; social and psychological evolution in space colonies; political allegiances and space colonies; and a program for educating today's children about space. Students with minimal social sciences background receive basic sociology references and guidance in other potentially worthwhile areas.

(3) Readings. All students receive extensive reading lists that correspond to speaker presentations and add items relevant to the social sciences.

(B) Astronautical Sociology. Astronautical sociology is a graduate class that assumes some familiarity with the potential of space development. However, the course does start with a slide presentation on options, possibilities, and problems encountered in the behavioral systems to date. The course employs the seminar format, with discussion centered on readings and related research in the socio-psychological aspects of long-duration spaceflights. Also, the faculty extensively familiarizes students with research materials on space and briefs students on means of obtaining Soviet materials. Student assignments include searches of STAR and IAA, NASA classification systems, and other government and industry document systems.

II. Select Bibliography

General Sociology Texts

Jacob Bronowski. *Science and Human Values.* Harper & Row, 1956.

Neil J. Smelser. *Sociology.* Prentice-Hall, 1981.

Astronautical Sociology

B.J. Bluth. "Alternative Social Structures in a Vacuum." In: Richard van Patten, Paul Siegler, and E.V.B. Sterns (eds). *The Industrialization of Space: Advances in the Astronautical Sciences.* San Diego: Univelt, Inc. Vol. 36, II, 1978.

B.J. Bluth. "Consciousness Alteration in Space." In: G. O'Neill (ed). *Space Manufacturing 3.* American Institute of Aeronautics and Astronautics, 1980.

B.J. Bluth. "Constructing Space Communities, A Critical Look at the Paradigms." In: R. Johnson, et. al. (eds). *The Future of the U.S. Space Program, Advances in the Astronautical Sciences.* San Diego: Univelt, Inc. Vol. 38, 1979.

B.J. Bluth. "Social and Psychological Problems of Extended Space Missions." In: *Global Technology 2000.* American Institute of Aeronautics and Astronautics, 1980.

B.J. Bluth. "Sociological Aspects of Permanent Manned Occupancy of Space." *AIAA Student Journal.* Fall 1981, pp. 11-15, 48.

B.J. Bluth. "Soviet Space Stress." *Science 81.* Vol. II, No. 7, September 1981, pp. 32-35.

B.J. Bluth and S.R. McNeal. "Influential Factors of Negative Effects in the Isolated and Confined Environment." Proceedings of the Fifth Princeton/AIAA/SSI Conference on Space Manufacturing.

B.J. Bluth and S.R. McNeal. *Update on Space: Volume I.* National Behavior Systems, 1981.

S. Cheston and D. Winter. *The Human Factors in Outer Space Production.* American Association for the Advancement of Science, 1980.

O.G. Gazenko, V.I. Myasnikov, K.K. Ioseliani, O.P. Kozerenko, and F.N. Uskov. "Important Problems of Space Psychology: As Evidenced by the Salyut 6-Soyuz Manned Missions." Paper presented at the XXVII International Congress of Space Medicine, 1979.

Robert Helmreich, John Wilhem, Trieve A. Tanner, Joan E. Sieber, and Susan Burgenbauch. *A Critical Review of Ames Life Science Participation in Spacelab Mission Development Test III: The SMD Management Study.* NASA TM 78494. June 1978.

Nick A. Kanas and William E. Fedderson. *Behavioral, Psychiatric, and Sociological Problems of Long-Duration Space Missions.* NASA TM X 58067, October 1971.

J.A. Rummel, et. al. *Spacelab Mission Development Test III (SMD III) Final Report: Scientific Experiments.* Vol. I, JSC-13950.

Sherman P. Vinograd. *Studies of Social Group Dynamics Under Isolated Conditions.* NASA CR-2496, December 1974.

III. Syllabus

California State University, Northridge
Course: Update on Space
Instructor: B.J. Bluth

The 1979 Update on Space was an educational experience offered as a sociology course through California State University, Northridge. Students, paraprofessionals, and professionals were invited to participate in a multifaceted program designed to provide the most up-to-date information of space-related activity in several different disciplines.

The major facets of the program included:

Speaker presentations
An agenda of knowledgeable people actively involved in space-related activity presented up-to-date information in their areas of expertise. A list of speakers and the titles of their presentations are included.

Field Trips
TRW facilities
Jet Propulsion Laboratory
Rockwell Space Shuttle Mock-Up

Luncheon Program
Seven to twelve class participants accompanied each speaker to lunch for an informal exchange of information and ideas. Students paid for their own lunch and contributed towards the cost of the speakers' lunches.

Participant Feedback
Following completion of the course, extensive participant feedback was solicited by survey.

Schedule & Topics

Week #1
Introduction
Tom Logsdon, Rockwell International. "The Science Fact of Science Fiction."
George Butler, Director, Advanced Space Concepts, McDonnell Douglas Astronautics. "Manned Space Platforms—Past, Present, and Future."
Dr. Richard Johnson, Chief, Biosystems Division, NASA, Ames Research Center. "Design Considerations for Space Habitats."
Gary Hudson, President, The Foundation. "The Commercial Use of Space."

Week #2
Bob Hammel, Manager, Space Processing Applications, TRW. "Materials Processing in Space."
Trip to TRW facilities.
Dr. B.J. Bluth. "Authority Conflict and Astronaut Stress."
Richard A. Colla, President, Rico-Lion, Ltd. "Television and Space Realities."

Week #3
Trip to Jet Propulsion Laboratory: Voyager Fly-By of Jupiter.
Curtis Graves, NASA, Chief of Education and Community Affairs. "Educational Resources and Problems."
Dr. Peter Vajk, Science Applications, Inc. Author of *Doomsday Has Been Cancelled* and SAI *White Paper on Alternative Financing for SPS.*
Jerry Hanley, Manager, Solar Power Satellite Project, Rockwell International. "Solar Power Satellites."
Dr. Rein Turn, Process Design, TRW. "Computers in Space and the Future."

Week #4
Captain Stan Rosen, USAF, Spacecraft Manager of the Defense Satellite Communications System Program Office.
Dr. Joe Angelo, Los Alamos Scientific Laboratory. "The Role of Man in Space: Payload Specialists and Non-Career Astronauts."
Trip to Rockwell International Shuttle Mock-Up. Presentation by John Dunstan, Instrumentation Systems, Rockwell. "The Landsat Program."
Dr. Kirk Stone,* Research Professor, Department of Geography, University of Georgia. "Selection of Settlers for Outer Space Colonizing."
Day open for trip to Apollo Exhibit at Museum of Science and Industry.

Week #5
Dr. Robert Helmreich, Professor and Chairman, Graduate Program in Social Psychology, University of Texas, Austin. "Psycho/Social Aspects of Habitats."
Sandy Shokocious, Biochemist and co-author of *Life Extension.* "Extending Life and Intelligence in the Future."

Howard Nellor, Hardword Project Manager, Tracking Data Relay Satellite System, TRW and Colleen Feldman. "Industry and Government in Space Programs."
Dr. Sally Ride, NASA, Astronaut Candidate. "Women in Space."
Durk Pearson, TRW. "Inertial Confinement Fusion Propulsion."

Week #6
Dr. Stephen Cheston, Professor and Associate Dean of the Graduate School, Georgetown University. "Space Social Science: An Emerging Discipline."
Al Kazanowski, Senior Member of the Technical Staff, Advanced Programs Department, Space Division, Rockwell International. "The Russian Space Program."
Dave Reed, Member of the Technical Staff, Advanced Programs Department, Space Division, Rockwell International. "The Starraker."
Maxwell W. Hunter II, Assistant to the Vice President of Research and Development for Strategic Affairs, Lockheed Missiles & Space Co. "Laser Propulsion Concepts."
Dr. Krafft Ehricke. President, Space Global, Inc. "The Extraterrestrial Imperative."
*Dr. Stone was unable to attend and S.R. McNeal of Loyola University presented a briefing on the public response to the Chicago Spacewatch Program.

Readings [all required readings noted with *]

Week #1
*O'Neill. *The High Frontier.* Or Heppenheimer. *Space Colonies.* Should be read early as they constitute the necessary background for the whole course.
Bova. *Analog Science Fact Reader.*
Stine. "Science Fiction is Too Conservative."
Logsdon. *The Rush to the Stars.*
*NASA. *Why Men Explore.*
*Salkeld. "Space Colonization Now." (xerox reader)
NASA. *Skylab, Our First Space Station.*
Worlds Beyond. Input 8.1.
Johnson. *Space Settlements: A Design Study.*
*"Private Space Shuttle." (reader)
Worlds Beyond. Sequences 9, 10, 11.
Stine. *The Third Industrial Revolution.*

Week #2
**Space Humanization Series (SHS).* Von Puttkamer. "The New Age..."
Space Shuttle.
NASA. *Apollo-Soyuz Pamphlets 7 & 8* (on Biology and Technology in O-g).
**NASA Facts.* "The Space Shuttle."
**SHS.* Sieber. "Well-Being..."
Worlds Beyond. Sequences 2, 3, 4.
Brand. *Space Colonies.* Schweikart, pp. 110-13.
Brand. *Space Colonies.* Berry, pp. 82-85 and selections from pp. 33-69.

Week #3
**NASA Facts.* "The Voyager Mission."
**SHS.* Logsdon. "The Policy Process..."
Bronowski. *Science and Human Values.*
Vajk. *Doomsday Has Been Cancelled.*
Worlds Beyond. Sequences 6 & 7.
Brand. *Space Colonies.* Schweikart, pp. 74-81.

Week #4
*"The New Military Race..." (reader)
**SHS.* Michaud. "The Anti-Satellite..."
*"Astronaut Selection and Training." (NASA handout)
Worlds Beyond. Sequence 9.
**SHS.* Salmon. "Power Over..."

Week #5
*Helmreich. "Psychological Considerations..." (reader)
*Prieser. "Habitability Considerations..." (reader)
Rosenfeld. *Prolongevity.*
*Stine. "Govt. & Industry..." (reader)
**SHS.* Chafer. "Space Policy..."
*Review: *SHS.* Sieber. "Privacy..."
Review: "Astronaut Selection..."
Brand. *Space Colonies.* Schweikart, pp. 138-45.
Worlds Beyond. Sequences 15 & 16.

Week #6
**SHS.* Cheston. "Space Social Science Suggested Paths..."
**SHS.* Chafer. "Space Policy..."
Review: "New Military Race..." (reader)
Review: *SHS.* Michaud.
Brand. *Space Colonies,* pp. 12-21.
*Ehricke. "The Extraterrestrial Imperative." (reader)

Very little work has been done on the sociological implications of the move into space. Students taking the course for credit are asked to write a term paper on some aspect of the sociological dimension, using proper library research methods and term paper format and covering at a minimum fifteen pages. The paper will be due the last day of class.

The subject matter of the paper should be seen from a perspective taken from the social sciences, sociology in particular; however, the topic should be one that is of particular interest to you. Interest has been shown in this course, and some of the papers may be published in complete or summary form in various journals or books, depending on their quality and general interest.

Since the backgrounds of the students taking the course vary considerably, that will be taken into consideration in the evaluation of the papers. Please give a brief indication of your academic status in the beginning of your paper.

In the event you are at a loss for a topic, one technique might be to take an introductory sociology textbook and ask how humanity's move into space might be a source of change or difficulty. For example, you could look into the chapter on poverty, consider the suggested origins and causes of poverty, and then ask if this set of conditions would apply in space settlements, and, hence, if we could expect to have poverty in the habitats humans build in space. Some further examples of potential project areas are:

1. Identify some of the elements of culture and social systems that are built up as adaptations to the physical environment of planet Earth, such as time, space, land use, water, etc. and consider the ways such values and norms might be changed by moving into completed artificial habitats in space. What would be the significance or potential impact?

2. Language is a vital social invention that acts as a glue for society. How much do you think the language of space settlers will become unique to them, and what effect could that have on the communication and interaction with Earth? (This would require that you examine the dynamics of language development and use, etc.)

3. Examine the sociological literature on the causes of one of the following and project the various possibilities for their development or lack of development in space settlements. Suggest some procedures that might be used in trying to prevent the development of the following in space settlements: Crime, Delinquency, Suicide, Anomie, Prejudice, Addiction, Poverty, War, etc.

4. The "Significant Other" and "Reference Groups" are important sociological concepts. How might these processes of socialization be affected by the move to space and what might be some of the consequences?

5. Stratification is an important sociological concept for understanding the divisions that arise in societies and the distribution of wealth, power, and mobility. Consider the origins and functions of stratification and project the ways stratification might develop in space settlements and the impact of such developments.

6. Many modern institutions have been subjected to tremendous pressures in modern technological society. Choose one of the following and consider the ways that institution might change in space settlements as well as the importance of such changes:

Marriage	Family
Education	Religion
Politics	Bureaucracy
Military	Work
Leisure	News Media

7. There are serious proposals for international space settlements. What problems and possibilities do you see in such a situation?

8. A number of our speakers indicate that humans will experience a radical change of consciousness when they move into space—an evolution in consciousness will take place. Do an in-depth analysis of this idea from the perspective of social science.

9. Rosabeth Kanter has developed a stringent set of commitment mechanisms for the development of community in her book, *Commitment and Community*. At the same time, some of our speakers are suggesting that the trend for development of the quality of life in space should follow the ideas of Abraham Maslow for self-actualization. Do you recommend such a course for the planners of space settlements?

Challenger, July 4, 1982 by Ron Cobb, acrylic, 45″ by 32″.

Appendix Three

Interdisciplinary Approaches

Interdisciplinary Courses

Case Study: The Teaching of an Interdisciplinary Course in the Social Science Aspects of Space and the Course Syllabus

T. Stephen Cheston
Graduate School
Georgetown University

I. The Course

In Spring 1978, Georgetown University offered an undergraduate interdisciplinary social science course on space, "The High Frontier: Technology, Diplomacy, and Human Values." A year prior to the course, Georgetown established a faculty coordinating committee comprising professors in physics, history, philosophy, political science, business administration, and theology. Following careful deliberation, the group chose as an integrating theme a space technological system with major economic implications, specifically, an Earth-Moon industrial operation drawing raw materials from the Moon or asteroids parked in Earth orbit and generating energy from solar arrays in space. With the technological integrator in place, the committee decided to provide further focus by emphasizing the impact of the technological system on international relations and fundamental human values (e.g., social justice, freedom).

The committee then devised a specific teaching plan, dividing the course into five major units:

(1) Technological potential and limitations;
(2) Economic constraints and business opportunities;
(3) Literary, historical, and religious analogies and insights;
(4) Diplomatic and political constraints; and
(5) Social organization and experimentation.

Committee members then proposed topics for each lecture, noting two or three issues that the lecture should either address directly or encompass by providing relevant information or analytical techniques to students. Each unit concluded with a discussion session to clarify the lecture materials, stimulate student activity and reflection, and apprise the faculty coordinating committee of student views on issues raised by the course. This built-in feedback system helped the faculty assess the need to modify materials in the latter part of the course and provided general guidance relevant to offering the course in the future.

The committee then considered the question of course staffing. By committee appointment, one of the members assumed the responsibilities of course coordinator and incorporated the course into his regular teaching schedule. The committee members scheduled themselves for many of the lectures. However, the committee felt that certain lecture topics were within the specialties of either Georgetown faculty not on the coordinating committee or, in some cases, professionals not affiliated with the University. The committee decided that guest speakers should be strictly limited—despite the wealth of qualified professionals in the Washington area—because guest speakers would be unfamiliar with the structure and aims of the course and, consequently, would lecture largely on their own terms. After a careful review of available professionals, the committee invited three guest speakers: a physics instructor from Princeton University, a NASA official specializing in advanced technological planning, and a State Department official familiar with international space policy issues. The course coordinator familiarized the professionals about the course beforehand, and the resulting lectures were well synchronized with the material presented by the Georgetown faculty.

The lecture schedule and discussion topics included the following elements.

(A) Technological potential and limitations

A Georgetown physicist, a Princeton physics instructor, and the NASA expert discussed:

(1) the current state of space technologies and projected development schedules.

(2) space industrial facilities, including precise descriptions of manufacturing, energy production, and service activities.

(B) Economic constraints and business opportunities

Members of the departments of economics, philosophy, and theology and of the School of Business Administration presented lectures, including analyses of issues such as:

(1) probable costs of the proposed industrial system and possible economic benefits.
(2) implications of the proposed system for national energy policy and general economic policy.
(3) the role of public and private institutions and corporations in the development of the proposed system.
(4) ethical norms relevant to investment decisions and public policy questions, including: What should be done? How should the industrial system be structured to avoid demeaning important societal values? Who should make the policy? Who should implement policy? Who should benefit?

(C) Literary, historical, and religious analogies and insights

A physicist with expertise in science fiction and members of the departments of history, political science, philosophy, and theology analyzed:

(1) the image of the frontier and the relation of the proposed technological system to American history and culture.
(2) the role of science fiction in stimulating the collective imagination and molding attitudes toward technology.
(3) the effects of the proposed system on human self-awareness, especially with regard to the problems of human autonomy, creativity, and manipulation.
(4) the moral limits to technology and their likely effectiveness.
(5) the images of technological humans in contemporary society in literature, sociology, and philosophy.

(D) Diplomatic and political constraints

Lectures were delivered by a history department member specializing in the impact of technology on international relations and the State Department expert in space affairs. The speakers addressed the relationship of the proposed system to:

(1) East-West problems, such as: possible military uses, destabilizing effects, and impacts on Soviet-American cooperation.
(2) North-South problems, such as: use of scarce resources and participation by newly developed countries.

(E) Social organization and experimentation

Faculty from the departments of psychology, history, and political science discussed:

(1) Human behavior in closed environments.
(2) The proposed system's long-term relationship to experimental societies, including: comparisons of utopian models in colonial experience with communities envisioned in contemporary science fiction; and the impact on social processes in a colonial society, including dependence on and autonomy from a parent society and freedom and authority within a colonial society.
(3) Colonial societies as a mirror of and metaphor for a parent society and as learning tools to understand contemporary social organization and policy.

The principal course requirement for students was preparation of a term paper, developed in consultation with the lecturer having the greatest expertise in relevant subject matters. The course coordinator reviewed all papers to maintain consistency in grading standards. Following completion of the course, a University administrator met privately with students to obtain their frank

assessments of the course. Students were uniformly favorable in their appraisals, noting the importance of ensuring that each speaker was fully aware of the preceding lectures to avoid redundancy or unwarranted assumptions that the students have knowledge prerequisite to the lecture.

An interdisciplinary course is a labor-intensive activity, requiring a great deal of advance planning, especially if a number of speakers are scheduled. Inadequate advance planning can severely jeopardize the quality of the course. Additionally, one individual should be charged with the principal responsibility for course coordination, even if an activist coordinating committee exists. Basic course logistics, continuity, and standards require such an approach.

On balance, the Georgetown course seemed very worthwhile. A number of students indicated that the course had provided fresh insights into other University course work.

II. Syllabus

Georgetown University
Course: The High Frontier: Technology, Diplomacy, and Human Values
Instructor: T. Stephen Cheston

This interdisciplinary course is intended to explore the relevance of considerations drawn from the social sciences and the humanities to the development of technology, specifically, the industrial utilization of space. The course will consist of a series of lectures on different questions raised by the prospect of industrialization and colonization in space. These lectures will be given by specialists (see below) in physics, business, economics, philosophy, theology, history, government, and social psychology.

The issues to be covered include:

(1) an introduction to physical and technological possibilities and limitations for projected industrial activities in space;
(2) economic assessment of the project and business opportunities;
(3) the project as seen in relation to the American social and intellectual traditions and in relation to religious and political imagination;
(4) political constraints and international demands on the project; and
(5) problems of colonial society in space.

Other topics to be considered will be: the history of the U.S. space program, space law, and parallel experiences of colonization. While the course deals with possibilities presented by current technology, the methods of reflection used in the course will be mainly those characteristic of the humanities and the social sciences. After each section of the course, there will be a session for discussion of issues.

Lectures to be given by:
Dr. O'Leary, Physics Department, Princeton University
Dr. Matthews and Dr. Morelli, Physics Department, G.U.
Dr. Cheston, associate dean, G.U. Graduate School
Dr. Sieber, the Kennedy Institute
Dr. Tesar, School of Business Administration, G.U.
Dr. Ferkiss, Government Department, G.U.
Rev. Curran, S.J., History Department, G.U.
Rev. Murphy, S.J., German Department, G.U.
Rev. Langan, S.J., Woodstock Theological Center
Mr. von Puttkamer, Office of Space Flight, NASA
Mr. Michaud, State Department
Dr. Pinkard, Department of Philosophy, G.U.
Dr. Davids, History Department, G.U.

Course coordinator: Rev. John Langan, S.J.
Woodstock Theological Center

Future Studies

Scenarios, Readings, and Syllabi for Future Studies

Kerry M. Joëls
Curator, Space Future Studies
National Air and Space Museum

I. Some Useful Scenarios

- Products are manufactured in space and produce profits on Earth.
- The Shuttle proves inadequate to carry tonnage required for space industries.
- The nation's economy takes a serious downturn.
- The Europeans sell hundreds of launches on their expendable boosters.
- The Soviet Union announces a manned mission to Mars.
- A multinational oil company decides to build a commercial shuttle to provide launch services.
- The national resolve to continue space exploration waivers in the wake of a serious Shuttle accident.
- A product manufactured in the microgravity of space—e.g., a drug that slows the aging process, a crystal that revolutionizes the semiconductor industry, biologicals and pharmaceuticals that virtually eliminate several diseases—creates a dramatic impact on social or economic structures.
- Solar power satellites prove marginally feasible, and the Arab countries invest money to have the satellites built and, consequently, own the power satellites.
- Studying planetary data provides clues to accurate long-term weather prediction on Earth, but more detailed analysis is needed.
- Third World nations block expansion and utilization of radio frequency spectrums and geosynchronous orbit slots.
- International concern over the militarization of space intensifies.
- A radical launch vehicle breakthrough reduces the cost of a pound of payload from $2,000 to $10.
- A radio transmission of extraterrestrial origin is received.
- Communications satellite costs average $1-2 per hour for audio, video, and data-two-way transmissions.
- A space action lobby receives massive public and political support, or the U.S. assigns high priority to accelerated space exploration.
- A breakthrough in communication satellite engineering makes one thousand television channels available to every household in the U.S. or the world.
- A company or a nation obtains a monopoly on remote sensing of mineral, agricultural, and other resources.
- Political activists make aerospace programs and installations the target for media campaigns and demonstrations.
- A major space effort generates half a million jobs.
- Electronic universities offer accredited degree programs via media.
- A space mission discovers a group of asteroids or a lunar site containing tons of rare and strategic metals or minerals.
- Nuclear war seems imminent, and a large self-supporting space station to house 100,000 people is under construction.
- A fundamental breakthrough in artificial intelligence eliminates the need for staffed space missions.
- A test solar power satellite "blows out" some communications satellites, but transmits power successfully.
- The European Space Agency and the Soviet bloc agree to build a Eurograd space station for 1,000 cosmonauts.
- The Space Telescope detects exploding X-ray objects that destroy life in whole galaxies at regular intervals.
- Fusion energy initiates another era of cheap energy for Earth.
- A new ice age reduces the world's food growing areas, but solettas (i.e., satellite-based solar reflected mirrors) demonstrate the capability to extend growing seasons.

- Remote sensing discovers vast oil or mineral reserves in relatively accessible and politically stable areas, or in the polar regions.
- The U.N. is authorized to establish a "human migration and space utilization" organization.

II. Some Useful Books

Kenneth Boulding. *The Meaning of the Twentieth Century.* Harper and Row, 1962.

James Bright. *Technological Forecasting for Industry and Government: Methods and Applications.* Prentice-Hall, 1968.

T. Stephen Cheston and David Webb. *The Space Humanization Series.* Institute for the Social Science Study of Space, Vol. 1, 1979.

Jerry Grey and Christine Krop. *Space Manufacturing III.* American Institute for Aeronautics and Astronautics, 1979.

Marilyn Ferguson. *The Aquarian Conspiracy.* Tarcher, 1980.

Willis Harmon. *An Incomplete Guide to the Future.* San Francisco Books, 1976.

Ehrich Jantsch. *Technological Forecasting in Perspective.* Organization for Economic Co-operation and Development, 1967.

Thomas Jones. *Options for the Future.* Praeger, 1980.

Herman Kahn. *The Next 200 Years.* William Morrow, 1976.

Robert Maidment and Russell Bronstein. *Simulation Games: Design and Implementation.* Merrill, 1973.

John McLucas and Charles Sheffield. *Commercial Operations in Space 1980-2000.* Vol. 51, Science and Technology Series. American Astronautical Society, 1981.

Gerard O'Neill. *The High Frontier.* Bantam, 1978.

Gerard O'Neill. *2081.* Simon and Schuster, 1981.

E.F. Schumacher. *Small Is Beautiful.* Harper and Row, 1973.

Fannie Shaftel and G. Shaftel. *Role-Playing for Social Values: Decision Making in the Social Sciences.* Prentice-Hall, 1967.

Malcolm Shaw. *Role-Playing: A Practical Manual for Facilitators.* University Associates, 1980.

Alvin Toffler. *The Third Wave.* Bantam, 1980.

J. Peter Vajk. *Doomsday Has Been Cancelled.* Peace Press, 1978.

III. Syllabus

University of Minnesota
Course: Education in Future Social Systems
Instructor: Arthur M. Harkins

Description

Interdisciplinary inquiry into problems of social specialization and generalization; projections and analysis of long-range (thirty years or more) social and technological trends related to education.

Comment

The purpose of the course is to describe and explain the basic forms of theory, methodology, and method used in the research, creation, and evaluation of alternative social and educational futures. Theoretical justifications for the rigorous study of the future are critically examined, especially those associated with "engineering"—or architectonic—systems approaches to social and education reconstruction.

1. To provide a systematic introduction to futures study at the graduate level for students interested in education:
   Why look to alternative futures in society and formal/informal education;
   What to look at in alternative futures, such as negative or positive futures; and
   How to look at alternative futures, such as discovery and invention perspectives and forecasting methodologies.
   The educational *policy* implications of the above.
2. To identify and systematically analyze practical problems encountered in introducing a new field to graduate education students and to relate that field to other disciplines and areas of study, for example: sociohistorical/systemic studies of education; anthropological/systemic studies of education; sociological/systemic studies of education; legal/systemic studies of education; educational policy implications of the above.
3. To equip and motivate education graduate students to pursue systematic productive studies of alternative educational futures within their own major fields, further developing their understanding of futures methods and their critical appraisal of futures study. For example, from policy and other perspectives, how are major features of their fields: Forecasting? Developing along mutually supportive or conflicting lines? Shapable? Not controllable?
4. To pursue points one through three within the framework of *comparative* general systems thinking and analysis, stressing educational policy issues.
5. To identify needs for systematic curriculum development in futures study, in itself and within students' areas of preparation through: library and field research; brainstorming with fellow students; proposals for, or scenarios about, alternative curricular futures, together with their policy implications.

Relationship to Other Courses

An orienting and overview course for those wishing a study of socio-educational futures; useful as a balancing perspective for those whose studies have been largely historical/contemporary in focus.

IV. Syllabus

University of Houston, Clear Lake City
Course: Study of the Future
Instructor: Christopher Dede

Texts

Thomas E. Jones. *Options for the Future.* Praeger, 1980. A packet of selected articles. Various course handouts.

Methodology

This course will utilize a combination of lectures, readings, simulations, guest experts, and films to generate group discussions on the field of futures research.

Objectives

(1) To give an overview of the history and current status of the field of futures research.
(2) To describe the major schools of thought on the future, with illustrative examples of prominent individuals in each.
(3) To depict the major organizations active in forecasting and their typical activities.
(4) To indicate the relationship of future studies to similar fields (such as policy analysis, strategic planning, and technology assessment).
(5) To discuss the structure of knowledge and the epistemology of futures research.
(6) To evolve a qualitative sense of the relative magnitudes possible in numerical data and to indicate the extent of the base of knowledge on which forecasts draw.
(7) To present a synthesized picture of the next decade, its major issues, and likely outcomes of alternative present choices.
(8) To convey the ability to be an intelligent consumer of futures forecasts.

V. Syllabus

University of Houston, Clear Lake City
Course: Research Methods for the Future
Instructor: O.W. Markley

Purpose and Description

This is an introductory survey course relevant to students in business, educational futures, public affairs, and studies of the future. Its purposes are:

(1) To give an overview of methodological approaches, research methods, and forecasting techniques that are used in the field of futures research.
(2) To develop understanding and working skills in using modern information retrieval techniques, including on-line computer-based searching of bibliographic data banks.
(3) To provide a familiarity with the strengths, weaknesses, and typical applications of typical methods and techniques of importance.
(4) To encourage a critical orientation when dealing with the methods and results of futures research.

Format and Topics

This course will utilize a combination of lectures, readings, homework assignments, and guest speakers, as well as continuing discussion of the materials being considered.

Major topics will include:

(1) Conventional research as contrasted with futures research.
(2) A futures research case study (illustrating the three principal aspects of futures research).
(3) Finding futures facts fast.
(4) Monitoring and updating of current trend reports.
(5) Characteristics of principal methods and techniques.
(6) Human factors and other characteristics of futures research as practiced in business, government, and think tanks.

Debate Analyses

Guidelines for Using Debate as an In-Class Tool

Alfred C. Snider
Assistant Professor
University of Vermont

When debate is employed as an in-class educational tool, many of the detailed rules which govern interscholastic and intercollegiate debate can and should be jettisoned for classroom use, although instructors may find it useful to consult with an experienced debate coach, if one is available. Basically, teachers who employ in-class debates as an educational tool should consider the following factors when organizing a debate:

(1) The instructor should designate a specific, narrow topic for discussion. The topic should call for a change in policy, or sometimes in value, from that advocated by the current system (or status quo). The topic should be structured as a resolution (i.e.: Resolved: That . . .). Usually, the topic will call for a specific agent—often the federal government—to take action to make a policy change.

(2) The affirmative speaker or team (usually two people) should support the topic, calling for a policy change. The negative speaker or team should either advocate the present system's policy (including any reasonable progress that the system can be expected to make) or support an alternative policy which is not the present system and is not the affirmative plan. For simplicity, the instructor probably should specify the system that the negative must support. In the end, both the affirmative and the negative should defend one policy system, and the debate should compare the two policy systems.

(3) The affirmative should initiate discussion of the harms caused by the present policy system (or the advantages to be gained by supporting the affirmative plan) and the inherent structures and/or attitudes within the present system which prevent policy changes that would alleviate or eliminate the harms (or achieve the desired advantages). The affirmative also should present a relatively detailed plan that does eliminate the harms or gain the advantages and represents a manifestation of the designated topic. The affirmative has the right to assume passage of this plan for purposes of argumentation (i.e., the negative cannot claim that the plan would not be passed by Congress or the agent specified in the topic); however, any attitudes that might prevent passage of the plan can be cited by the negative as motivations for circumvention of the plan, as long as the negative also specifies the means and impact of any circumvention.

(4) The negative should initiate discussion of features of the present system (or the policy system advocated by the negative) that do or will tend to alleviate the harms or to gain the advantages cited by the affirmative. The negative also is responsible for analyzing the affirmative plan. One focus of this analysis is whether the plan actually can achieve its advantages or eliminate the cited harms (i.e., is the plan structure sufficient to overcome attitudes, still-existent legal or social structures, and other relevant factors that might impede the plan's success). Another focus of the plan analysis emphasizes any disadvantages that would occur because of the adoption of the plan (i.e., does the plan worsen any existing problems or create totally new ones).

(5) Each speaker or team should think through relevant issues, planning initial positions and subsequent responses in advance and developing organized, outline-form arguments. The instructor and other class members might help the debaters prepare such argumentation. Each speaker or team should use evidence to support such positions and arguments, although the strict requirement for evidencing all assertions can be relaxed for in-class debates, allowing the debate to focus on reason more than on evidence.

(6) The instructor should decide how many speeches will be allotted to each team, the length of each speech, and whether or not to allow cross-examination during one or more formally designated cross-examination periods (of course, a teacher might decide to permit heckling, but such a rule can encourage the rapid deterioration of a formal debate into a shouting match). The standard speech length and sequence in interscholastic and intercollegiate debates can serve as a guideline. In collegiate debates, each of four debaters gives two speeches (one constructive, one rebuttal), is cross-examined once, and cross-examines one other debater. Each constructive lasts ten minutes, each rebuttal five minutes, and each cross-examination period three minutes. Speeches proceed in the following sequence: first affirmative constructive (basic affirmative positions and plan); first negative constructive (defense of negative system vis-a-vis affirmative arguments); second affirmative constructive (defense and extension of affirmative positions); second negative constructive (analysis of affirmative plan); first negative rebuttal (defense of negative system in light of second affirmative constructive); first affirmative rebuttal (defense of plan in light of second negative constructive and defense of case in light of first negative rebuttal); second negative rebuttal (final defense of negative positions on affirmative analysis and affirmative plan versus the negative system); and second affirmative rebuttal (final defense of affirmative arguments and plan versus the negative system). After each constructive speech, the speaker who gave that speech is cross-examined by a member of the opposing team. Instructors may wish to shorten the debate by having fewer speeches. In addition, teachers may wish to make each speech slightly longer, allowing fuller discussion of important issues without the need for excessively rapid speeches. Preparation time between speeches may be appropriate.

(7) Debates can be unjudged, or the instructor or the class as a whole can decide whether the affirmative or negative won the debate.

The Use of Space Research in Intercollegiate Debate

Melissa Maxcy Wade and James M. Wade
Director of Forensics and Assistant Debate Coach
Emory University

College-level courses in argumentation usually are housed in the department of speech communication. Intercollegiate debate tournaments (or in-class debates) represent an important practical application adjunct to the theoretical study of argumentation.

During the summer of 1975, Emory University hosted a two-week summer forensics institute for high school students and teachers. While researching background information on the high school debate resolution (conservation of scarce world resources), the work of Gerard O'Neill came to the attention of the Emory staff. After several college seasons focused on debating the food crisis, the population explosion, the energy crisis, the scarcity of resources, and the increasing international tensions, the notion of industrializing space presented an intriguing possibility for tournament debating.

The 1975-76 collegiate debate resolution called for government creation of a comprehensive program to control land use in the United States. Emory debaters supplemented summer research on O'Neill's proposal by studying relevant scientific conference reports, government hearings, research study reports, periodicals, and newspapers. Virtually every source in the public sector was researched, with the resulting information catalogued and structured into advocacy arguments.

This early research on space issues was dominated by the work of O'Neill and Peter Glaser. General and popular periodicals[1] publicized their ideas, which stressed the long-term advantages of space development: abundant agricultural production; extension and possibly addition of territory; space manufacturing; and a supply of cheap, clean, and infinite energy. The *Congressional Record* constituted an excellent source of reprints and updated information. The early issues of the *L-5 News* during 1975 and 1976 reviewed the latest studies and reports. The 1975 *Future Space Programs*[2] hearings before the Subcommittee on Space Science and Applications (of the House Committee on Science and Technology) also were very informative. The hearings also launched proposals by O'Neill, Glaser, and tangential advocates into the arena of public policy debate. The short-term impacts of space industrialization and satellite solar power stations (SPS) were measured by studies such as the Chase Econometrics Associates analysis in 1976[3] and the Mathematica study in 1975.[4]

The research was incorporated into the argumentative position that the immediate investment of federal dollars into a comprehensive space development program would mitigate the world's critical problems before they became irreversible. Debate strategy emphasizes the significance of claimed benefits and the solvency (or effectiveness) of the affirmative plan versus the negative policy system (either the present system or a counterplan that does not support the topic as a policy solution). The significance of space industrialization and SPS was staggering in the debate context, and the research also documented plan solvency. Most evidence strongly suggested that the technology required for industrialization, colonization, or SPS was available and feasible (in terms of initial costs and maintenance costs). The clarity of the feasibility argument was critical to the success of the concept on the national debate circuit; because of the quality of available evidence, space issues assumed some prominence in tournament debating.

At one of the first tournaments of the 1975-76 school year (Middle Tennessee State University), one Emory team defended SPS as a negative counterplan against an affirmative plan calling for alternative means of nuclear waste materials disposal. The counterplan phased out nuclear energy on a timetable keyed to SPS output levels, and nuclear waste materials created during the transition were scheduled for disposal in space. Emory debaters also argued the counterplan against teams that advocated greatly expanded government ground-based solar energy programs as a solution to the energy crisis. Following the tournament, Emory staff members delivered a series of lectures on use of the SPS counterplan, heightening interest among team members. Further research and analysis refined and reassessed SPS arguments for future use.

During the 1976-77 collegiate debate season, the national debate resolution addressed consumer product safety. One Emory team refined the SPS counterplan, including a concise summary of the benefits of industrialization and colonization. The counterplan applied primarily to Harvard University's affirmative plan, which advocated nuclear energy over fossil fuels as a consumer product (in terms of health costs, dollar costs, short-term and long-term productive capacity, and environmental impacts). The affirmative version of the SPS case achieved higher than average success, as did the counterplan. In general, the consumer product safety topic did not lend itself to as many interpretations that were germane to the space debate as the previous topic had. However, the research base broadened considerably during the academic year, as O'Neill and other space advocates received more media attention. Government and private studies clarified and often supported the solvency and significance arguments critical to debate argumentation.

The 1977-78 debate resolution focused on felony law enforcement. Although space could not be applied to this topic, students were so intrigued with the notion of space industrialization that they voluntarily continued space-related research. The literature emphasized space industrialization; in addition, three books dealt extensively with the permanent occupancy of space.[5]

This voluntary research paid off when the 1978-79 debate resolution called for the United States government to guarantee employment opportunities to each citizen in the labor force. Researchers updated the impacts of space expenditures on employment opportunities, economic growth, and technological spinoffs; debaters then created an affirmative case and plan, as well as a negative counterplan position. The solvency evidence was very strong. The Chase Econometrics study in 1976 provided strong solvency,[6] and the 1975 Mathematica study documented spinoff benefits critical to the success of the affirmative case.[7] NASA's annual *Spinoff* report also supported the affirmative position. Some excellent negative positions were advanced against the case, but such arguments tended to stress short-term costs and were vulnerable to claims of long-term advantages. The majority of negative arguments somewhat vaguely developed potential risks such as military dictatorships in space, the launching of weapons into space, and concerns such as the fact that planes might be endangered by passing through a microwave transmission beam of an SPS.

In our near decade of coaching intercollegiate debate teams, we have never advanced an idea as stimulating to students as the notion of space industrialization, development, and colonization. Student enthusiasm suggests that space development has a healthy future in intercollegiate debating.

Footnotes

1. For example: *Time.* June 3, 1974, p. 51; *Physics Today.* September 1974, pp. 32-40; *Physics Today.* September 1975, pp.13-14; *Science News.* September 21, 1974, p. 183; *New Yorker.* June 17, 1974, p. 23; *Saturday World Review.* August 24, 1974, p. 32; *Fortune.* June 1974, p. 120; *Harpers.* June 1974, p. 6; *Popular Science.* September 1975, p. 65; *Sky and Telescope.* April 1975, p. 226; *Popular Mechanics.* May 1975, p. 94; "Space Colonies and Energy Supply to the Earth." *Science.* December 5, 1975.

2. *Future Space Programs.* Hearings before the Subcommittee on Space Science and Applications of the House Committee on Science and Technology. July 22-24, 29-30, 1975.
Also: *Future Space Programs.* Volumes 1 and 2. Hearings before the Subcommittee on Space Science and Applications of the House Committee on Science and Technology. September 1975.

3. Chase Econometrics Associates, Inc. "The Economic Impact of NASA R&D Spending." Bala Cynwyd, PA, April 1976.

4. Mathematica, Inc. "Quantifying the Benefits to the National Economy from Secondary Applications of NASA Technology." Princeton, N.J., June 1975.

5. Frederick Golden. *Colonies in Space.* Harcourt, Brace and Jovanovich, 1977; T.A. Heppenheimer. *Colonies in Space.* Stackpole Books, 1977; and Gerard K. O'Neill. *The High Frontier: Human Colonies in Space.* William Morrow and Company, 1977.

6. See footnote 3.

7. See footnote 4.

Touchdown at Press Site by Franklin McMahon, watercolor, 29½″ x 38″.

The NASA Art Program

The paintings that appear in *Social Sciences and Space Exploration* resulted from the participation of selected artists in the NASA Art Program. The NASA Art Program uses the medium of fine art to document America's space program for "the expansion of human knowledge of phenomena in the atmosphere and space . . . for the benefit of all mankind."*

*National Aeronautics and Space Act of 1958